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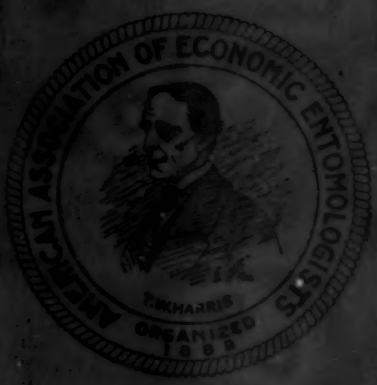

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American Association of Economic Entomologists Proceedings of the Forty-Third Annual Meeting

Thursday Morning Session, January 1

The session convened at 10:10 A. M., President Franklin Sherman presiding.

PRESIDENT FRANKLIN SHERMAN: The first paper on the program is by C. R. Cleveland.

AN EXPERIMENT WITH SUMMER OIL FOR THE CONTROL OF THE EUROPEAN ELM SCALE (*GOSSYPARIA ULMI* L.)

By C. R. CLEVELAND, *Chicago, Ill.*

ABSTRACT

Application of a summer or white oil emulsion in early July to nursery grown elms heavily infested by this insect produced highly effective control at 2% concentration of the emulsion. Data relative to influence of time and methods of application, insecticidal action of the oil, and tolerance of the trees to oil injury, are presented.

A severe infestation of the European elm scale, or bark louse (*Gossyparia ulmi* L.), on several large blocks of American and Cornish elms in the Greening Brothers' Nursery at Monroe, Michigan, was brought to the attention of the writer on the fourteenth of July, 1930. His advice concerning the control of this infestation was sought by the proprietors. Summer control was considered imperative because of the fact that no dormant control practice had been established; the elms in question had been sold for delivery in the fall of 1930; and a cleanup of the infestation was essential for release by the State Nursery Inspection Department.

Favorable results in control of this species by the use of a summer white oil emulsion had been demonstrated in three previous trials in the writer's experience, but conclusive evidence demonstrating a certainty of eradication by this means had not been established. Hence, the proprietors were advised that the writer believed as complete control probably could be accomplished by the use of summer oil as by any other means, and a cooperative experimental effort to that end was organized.

LIFE AND SEASONAL HISTORY. It so happened that the situation existing in this nursery was disclosed at an opportune time for the inauguration of spray control efforts. On July 14, examination disclosed young scale insects (crawlers) hatching very actively and crawling over the bark toward the leaves in great numbers. Young had already settled on the undersides of the leaves in abundance. Examination underneath the old female scales showed many with no young left in that position. Furthermore, fully 50% of the old scales were already quite dry and shrivelled. Some had already dropped from the bark. However, approximately 40 to 50% of the old scales still had young in greater or less numbers underneath and ready to emerge.

The indications were that emergence was at its height or slightly beyond that stage on July 14. The conditions were therefore favorable for a maximum effect to be produced by spraying with an effective summer contact insecticide, because of the following factors: (1) a high percentage of crawlers exposed to direct and immediate action of the spray, (2) the balance of those not yet emerged were already hatched and in a relatively susceptible condition and position for some effect of the spray by penetration underneath the old scale, (3) those not yet emerged at time of spraying, did emerge, however, within a relatively short time, and were thus in a proper condition to be affected by residual effect of the oil over and through which they must crawl to reach the foliage, (4) those on the leaves were still in a comparatively susceptible condition to action of the spray, if properly applied.

That emergence of this infestation in 1930 was apparently protracted beyond that period of time usual for this species was indicated by the report by Mr. Duvall, Nursery Superintendent, to the effect that he had observed emergence beginning on June 15. A spray of summer oil at that time was applied to one block of trees, but was put on so long before the peak of emergence was reached that its effect was apparently only partial, as disclosed by data presented later.

SPECIFICATIONS OF OIL. The summer (white) oil spray selected for this test was a commercial preparation, which may be designated as Summer Spray Oil Formula No. 20. It is in the form of a concentrated oil emulsion of creamy, semi-fluid consistency, white in color. It is one of the so-called colloidal emulsions, with oil droplets relatively small, uniform and very evenly dispersed throughout the emulsion, produced by special processes of manufacture, and by the selected nature and proportions of the oil, emulsifier and water elements. It is composed of approximately 65 to 66% actual oil, the balance being mainly emulsifier and

water. The emulsifier is of the inert (non-soap) type, of vegetable origin. Significant specifications of the white oil in this product are: viscosity at 100 degrees F., is 80 to 85 seconds; gravity, 34 to 34.5; volatility (British Transformer Method) about 2%; and sulfonation (de-Ong method) 3 to 4%.

Other properties of this emulsion are its high degree of stability in concentrated form but relatively quick breaking upon application in diluted form; ready and complete emulsification in all types of water; unusual degree of persistence of oil on surfaces to which it is applied, due to retaining power of emulsifier element; and lack of maximum degree of wetting power, (also due to type of emulsifier employed).

PROCEDURE AND METHODS. Four experimental blocks were sprayed on July 15 and July 18 with Summer Spray Oil No. 20 at the rate of two gallons of the emulsion to 98 gallons of water. Potash fish oil soap (30%) was added to the diluted emulsion at the rate of four pounds to one hundred gallons to provide more complete wetting. Blocks 1, 2, and 3 consisted of American Elms, eight to fifteen years old, and varying from approximately seven to fourteen feet in height. Block 4 was composed of Cornish Elms of the same age and size as the American variety. All blocks were generally infested throughout, although certain trees in each block were much more heavily infested than others. Trees selected for special observation and counts were an equal number in each block which showed as nearly an equal degree of the heaviest infestation as it was possible to find. No unsprayed checks were maintained, as the nursery naturally desired to effect a complete cleanup if possible.

Block 1 was sprayed on July 15; blocks 2, 3 and 4 on July 18. A Bean power sprayer giving a pressure of 222 to 275 pounds per square inch at the nozzle was used for all applications. A high pressure type spray nozzle with disk opening of one-eighth to one-sixteenth inch was used.

The spraying was done by the nursery spraying crew in charge of Mr. Duvall, as directed by the writer. Unusual care was exercised to spray all parts of the trees thoroughly, especially directing the spray upward underneath the trees to cover the lower surfaces of the leaves. Excellent coverage was secured in this way.

Block 1 was the only one of the experimental units sprayed more than once. This block received the June 15 spray formerly referred to in addition to the application July 15.

OBSERVATIONS AND RESULTS. Ten of the most heavily infested trees in Blocks 1 and 2 were examined on July 14. Young were hatching actively, and were found in considerable abundance already settled

on the leaves. This indicated little or no control from the June 15 application at first glance. However, a comparison of the number and condition of the young on the leaves in Block 1 and 2 was made to check on possible residual or other effects of the earlier spraying. Three of the most heavily infested leaves from each of five most heavily infested trees which could be found in each block were examined microscopically to determine the number and condition of young which had settled. The results are expressed in the following table.

TABLE 1. EFFECT OF APPLICATION JUNE 15 (ONE MONTH PREVIOUS TO MAXIMUM EMERGENCE). OBSERVATION JULY 14

Block No.	Treatment	No. trees examined	No. leaves examined	No. young dead	No. live	% dead
1	Sprayed 2% Oil No. 20 June 15	5	15	290	86	77.07
2	Not sprayed prior to July 15	5	15	192	288	40.0

Thus, there were almost twice as many dead insects on the leaves of the trees sprayed June 15 as on those not sprayed prior to this count, indicating a strong possibility that the early application had exercised some control by residual action. Furthermore, there were 104 more young on the unsprayed leaves, indicating a trend in the direction of some influence of the early spray in preventing a percentage of crawlers reaching the leaves. Also, it was noticeable that many of the young on the leaves of Block 2 were quite distinctly larger than any of those on Block 1, indicating the probability that many of those on Block 2 were of earlier origin than those on Block 1.

However, it was obvious that the application of June 15 had not been effective as providing an efficient degree of eradication.

An application of the No. 20 Oil plus potash fish oil soap as described above was made to several of the most heavily infested trees of Block 1 on the afternoon of July 14. Observations two hours following the application showed no moving crawlers, and thousands of quiescent young, apparently dead. Observation on the morning of July 15, 18 hours later, showed the same condition. However, observation at noon on July 15 showed the bark of these trees again liberally provided with moving crawlers, indicating that with the increasing warmth of the day, young were emerging from under the old scales. This block was then sprayed completely on the afternoon of July 15.

To ascertain the results of this application, and also subsequent applications to Blocks 2 and 3 on July 18, the most heavily infested leaves which could be found were collected from the worst infested trees in each block, and examined for live and dead young on later dates, namely July 26 and September 5. The results are shown in Table No. 2.

TABLE 2. EFFECT OF SUMMER SPRAY OIL NO. 20 APPLIED JULY 15 AND 18 ON MORTALITY OF YOUNG FOLIAGE INHABITING SCALES

Date of examination	Block No.	Treatment	Total No. young	No. dead	No. live	% dead
July 26	1	No. 20 Oil (2%) plus soap—July 15	172	172	0	100.0
	2	Do. July 18	808	778	30	94.39
	3	Do.	609	607	2	99.6
Sept. 5	1	As above	735	735	0	100.0
	2	Do.	357	357	0	100.0
	3	Do.	1073	1073	0	100.0

The results shown in the above table indicate an apparent complete destruction of the young, probably as a result of the combined effect of the spray on motile young on the bark, settled young on the leaves, and residual effect on young emerging following application. That there was some cumulative or residual effect on young which had reached the leaves following application is indicated by the increasing percentage of dead from the first to the second count.

A final inspection of all experimental blocks was made on October 28, after all the young scale insects on the leaves had migrated to the bark to hibernate. Ten trees in Block 1, ten trees in Block 2, five trees in Block 3 and four trees in Block 4, were examined. Those trees showing evidence of previous heaviest infestation were selected, and examined carefully, covering a minute inspection of all parts of trunks, branches and limbs from the ground upward to a height of about seven to eight feet. A number of additional trees which had been dug and carried into the packing shed were also examined to the extreme tops as a check on the field inspection. The results are shown in Table No. 3.

TABLE NO. 3. EFFECT OF SUMMER SPRAY OIL NO. 20 APPLIED JULY 15 AND 18 ON OVERWINTERING INFESTATION OF *Gossyparia ulmi*. OBSERVATION OCT. 28, 1930

Block No.	Variety	Treatment	No. trees examined	Number infested	No. not infested	No. hibernating young
1	American	Summer Oil No. 20 July 15	10	2	8	2
2	American	Summer Oil No. 20 July 18	10	3	7	25
3	American	Do.	5	1	4	8
4	Cornish	Do.	4	4	0	Fairly plentiful

The results noted above indicate very complete final control as shown by the overwintering infestation on all the American elms, with evidence of slightly less effective control on blocks sprayed on July 18. This was probably due to the influence exerted by the June 15 application in Block 1, which undoubtedly destroyed the earlier emerging scales and exercised a reducing effect on the numbers of scales emerging between June 15 and July 15, thus rendering the insects in this block which did reach the leaves, younger and less resistant to the action of the spray than those in Blocks 2 and 3.

The poorer results on the Cornish elms may be logically explained by the much denser nature of the foliage on this variety and the tendency of the leaves to curl quite tightly, thus making it decidedly more difficult to secure effective spray coverage.

SPRAY INJURY. No burning or other type of spray injury could be discerned on any of the trees of either variety sprayed with this summer oil at any time following any of the applications. This record is quite remarkable, considering the extremely hot and dry weather which prevailed immediately following the applications and which persisted for an unusual length of time. It indicates not only that the oil is essentially safe for application to foliage, but also that these two varieties of elms at least possess a high degree of tolerance to oil injury.

The following table (4), shows temperature and humidity records for Monroe, Michigan, over the crucial period involved.

TABLE NO. 4. TEMPERATURE AND RELATIVE HUMIDITY RECORDS AT MONROE, MICHIGAN OVER PERIOD OF PROBABLE INJURY EFFECTS OF SUMMER SPRAY OIL NO. 20

Date	Temperature Degrees F.		Relative Humidity		
	Max.	Min.	8 A.M.	Noon	8 P.M
July 15*	74	45	62	42	54
July 16	84	49	56	27	30
July 17	98	58	43	26	26
July 18*	101	64	37	23	28
July 19	105	75	43	40	38
July 20	102	75	63	43	43
July 21	103	80	48	36	64
July 22	90	70	81	51	59
July 23	85	62	76	57	56
July 24	97	62	67	35	28
July 25	102	69	52	43	41

*Spraying dates.

CONCLUSIONS

1. A summer white oil emulsion at 2% strength, exhibiting the characteristics of Summer Spray Oil No. 20, as described above, is highly effective in controlling the European elm scale (*Gossyparia ulmi* L.).

2. The addition of potash fish oil soap (30%) at the rate of 4 pounds to 100 gallons probably increases the efficiency of this spray by increasing the wetting effect.

3. For the best results application should be made at or close to the maximum emergence period of the young. This occurred in the test reported in 1930 about July 15 to July 18.

4. Extremely thorough application, with special care to cover the undersides of the leaves, as well as other parts of the tree, is essential to the most complete results.

5. Evidence indicates that this type of spray material controls by (1) immediate and direct kill of young on bark and leaves, (2) penetration under old scales and destruction of some of the hatched but unemerged young, and (3) residual killing effect on hatched and emerged young.

6. This type of white oil spray appears safe on American and Cornish elms, no injury having been produced under severe temperature conditions at and following application.

PRESIDENT FRANKLIN SHERMAN: The next paper is by F. L. Gambrell.

THE SPRUCE GALL APHID (*ADELGES ABIETIS*) AS A NURSERY PEST

By F. L. GAMBRELL, *New York State Agricultural Experiment Station, Geneva, N. Y.*

ABSTRACT

The spruce gall aphid (*Adelges abietis*) is an important enemy of Norway spruce in New York nurseries, and nurserymen often sustain serious economic losses due to the ravages of this insect. There are two generations, both of which occur on spruce. No alternate host appears to be involved. Results of some treatments employed in the control of this insect are included. Applications of miscible oils and bordeaux lubricating oil emulsions have given good control but have been attended in some cases by injury to the trees, which varied directly with the material and the concentrations used. Likewise, promising results have been secured from the use of lime-sulfur, soaps and nicotine. No injury has been observed following applications of these latter materials.

The increased interest in evergreens as constituents of ornamental plantings has been attended by the desire of a better understanding of the insects which attack them. The growing appreciation of evergreens is also reflected by the large production of such plants on the part of the nursery industry. According to figures compiled by the Bureau of Plant Industry, Department of Farms and Markets, Albany, New York, a total of 21,322,063 evergreens and 22,973,357 ornamental shrubs were inspected in New York nurseries during the season of 1928 and, needless

to say, numerous insect pests were encountered during the prosecution of this work. Some of the more important insect pests with which the nurserymen have to contend are the following:

The spruce gall aphid (*Adelges abietis*), spruce mite (*Paratetranychus ununguis*), pine leaf scale (*Chionaspis pinifoliae*), pine bark aphid (*Adelges pinicorticis*), woolly larch aphid (*Adelges strobilobius*), arborvitae leaf-miner (*Argyresthia thuiella*), euonymous scale (*Chionaspis euonymi*), juniper scale (*Diaspis carueli*), and various other species of aphids, scales and leaf-eating insects.

Probably one of the most important and destructive insects of evergreens under nursery conditions in New York is the spruce gall aphid. It is generally distributed thruout the state and in many cases the nurserymen are sustaining serious economic losses as a result of the ravages of this pest, particularly on Norway spruce. In some instances where plantings of infested trees have been allowed to grow without special treatment or have been neglected for a period of a few years, a large proportion of the trees have been rendered worthless. For example, in one block of Norway spruce composed of about 13,000 trees, two to four feet in height, it was necessary for the grower to dig out and destroy 500 of these trees. Another block which consisted of approximately 2,000 trees of from three to five feet in height were infested and deformed to such an extent that the entire planting was destroyed. In the first case, figuring the value of the trees at $1.75 each and in the second case at $2.25 each, which according to the growers represented prices as based upon carload shipments, the actual loss to these growers was respectively $875 and $4500.

Host Plants and Injury. The writer has observed this insect on both indigenous and imported species of spruce among which are the Engelmann spruce (*Picea engelmanni*). Colorado blue spruce (*Picea pungens glauca*), black spruce (*Picea mariana*), and the Norway spruce (*Picea abies*). Thus far, observations indicate that it is much more numerous and does considerably more damage on Norway spruce than any of the other species under consideration. Aside from the species already enumerated it has been recorded by other workers on white spruce (*Picea canadensis*) and occasionally on hemlock (*Tsuga canadensis*). The injury caused by this creature is rather striking and, as its name indicates, appears as a gall, which has been appropriately referred to as the "pine-apple gall," at the base of the new growth. These galls may number from a very few to as many as five to six hundred on a single nursery tree three feet in height. On account of the effect of insect

feeding upon the character of the growth, and the casting of the needles, coupled with the unsightly appearance of galls, trees which are heavily infested present a ragged and unsightly appearance.

RESUMÉ OF LIFE HISTORY. This particular species of Adelges presents some rather interesting and possibly some fundamental differences in regard to its life history which have been the subject of much discussion and speculation among some of the European workers. In the subfamily Adelginae many complexities of the life cycle or the variation of forms are exhibited. Two generations are required to complete the life cycle, and in practically every species there is an alternation of hosts as well as different forms in the different generations. Thus far the study of this particular species by American workers indicates that it is an exception to the general rule in that during the course of the life history it appears to be limited to spruce and does not migrate to an intermediate host. The following forms are observed in the life cycle of this particular species: First, *the fundatrix or apterous, agamic female* which overwinters as a nymph on the branches of the spruce; second, the *gallicola migrans* which develops from the eggs laid by the *overwintering fundatrix;* third, the *alate non-migrans* resulting from the *gallicola migrans* and which in turn lays eggs on the needles that develop into the *overwintering fundatrix* or *agamic female*, thereby completing the life cycle.

The eggs of the overwintering females are deposited just prior to the beginning of new growth at the bases of the buds and number from a very few to two hundred or more in a single mass. These eggs hatch within a short interval and the nymphs migrate to the bases of the needles. The bases of the needles already show some evidence of swelling due to the feeding of the overwintering females prior to hatching of the eggs. They begin to feed on the new growth and are eventually surrounded by the galls as they develop. These nymphs continue to develop within the gall and emerge after growth for the season has terminated, at which time the galls crack open and the nymphs crawl out and attach themselves to the needles, cast their last nymphal skins, and transform into the *alate non-migrans* females. These females deposit their eggs in masses of from thirty to fifty beneath their abdomen onto the needles and die in this position shortly after oviposition has ceased. It is from these eggs that the *fundatrices* or *apterous, agamic females* are derived.

CONTROL. It will not be possible within the limits of this paper to discuss or include in detail all of the data which has been obtained in our

experiments against the spruce gall aphid. However, the writer desires to call attention to the time, methods, and nature of the treatments and to indicate briefly the types of materials employed in the control of this insect, as well as to include certain data which is considered typical of the different types of insecticides used. Work on this particular phase of the problem was begun during the fall of 1928 and has continued up to the present time. Both fall and spring treatments have been given consideration, the former being directed against the overwintering nymphs and the latter against the later nymphal stages early in the spring. All of the applications were made with hand or power sprayers under nursery conditions. These experiments involve approximately 30,000 Norway spruce trees, ranging from five to twelve years old, and extend over a period of three years.

The materials used, for the sake of convenience here, can be divided into ten different categories. These are: miscible oils, bordeaux lubricating oil emulsions, tar distillates (English washes), soaps, nicotine, derrisol, tobacco and nicotine dusts, lime-sulfur, combinations of nicotine with soaps, Penetrol and oils, and combinations of lubricating oils and paradichlorobenzene, all of which have been used at various concentrations and some in combination with other materials. Fall applications were made about the first of November and the spring treatments about the middle of April, depending to some extent in each case upon weather conditions for the particular season in question, care being exercised in the case of spring treatments to avoid freezing weather as much as possible; but at the same time making sure to apply materials before there was any evidence of new growth.

The method of securing and analyzing the data on these treatments deserves some consideration and is discussed in order to facilitate a better interpretation of the data. Plats were staked out in the nursery rows and the number of trees in each are indicated in the tables. In making counts to determine the efficiency of these treatments each tree was carefully examined subsequent to the application and the number of galls produced during the preceding season was determined. At the same time the galls which developed during the current season were recorded. The same procedure was followed in the case of checks or untreated trees. It should be pointed out that in many plats there were trees which showed no galls for either year. This accounts for the seeming discrepancy as to the number of trees indicated in the tables. The percentage of control was determined by the following method: From the number of galls produced on untreated trees prior to and during the season in which the treatments were made the average factor of increase

or decrease in the number of galls was determined. This factor during the season of 1930 showed an increase of 1.176 galls per tree as based on counts from a large number of trees. By multiplying the total number of galls present during the preceding season by this factor is secured the number of galls which should have developed on these trees had no remedial measures been employed. Then by subtracting the actual number of galls which were produced on the treated and dividing the figure obtained by the expected number of galls the percentage control is calculated. The results secured in this manner compare quite closely to those obtained by the usual method of taking the average number of galls per tree before and after treatment and arriving at the percentage control in this way. Since both methods in our case lead to the same conclusions the former was employed in our calculations. For the sake of brevity a portion of the data is given, but the figures presented in Tables 1 and 2 are typical of the different treatments.

The results of the experimental work thus far may be briefly summarized as follows:

1. The spruce gall aphid is an important enemy of Norway spruce as grown in New York nurseries and it may also attack other species of spruce.

2. The life history of this species conforms in a general way to that of other members of the Adelginae, but differs in that no alternate host appears to be involved. Two generations are required to complete the life cycle. Eggs of the *apterous, agamic females* are deposited in masses of from one to two hundred at the bases of the buds, and under New York conditions are laid about the first of May. These eggs give rise to the *gallicola* nymphs which continue their development within the galls and from which develops the *alate non-migrans females*. These females deposit their eggs on the needles in masses of from thirty to forty, beginning about the first of July, and from which are produced the *apterous, agamic* females which overwinter on the branches of the spruce. This latter stage serves to complete the life cycle.

3. The application of miscible oils and bordeaux lubricating oil emulsions in the main have afforded very satisfactory control but in some instances have been attended by rather serious injury to the trees. Differences have been detected in the degree of injury, both from the standpoint of materials and the dilutions used. Combinations of nicotine with Penetrol, soaps and oils and spray mixtures consisting of either lime-sulfur or soap uncombined have shown promising results, none of which produced any apparent injury to the trees.

TABLE 1. RESULTS OF TREATMENTS AGAINST THE SPRUCE GALL APHID (*Adelges abietis*)

Treatment 1930	Number trees in plat	Number trees infested 1929	1930	Total galls 1929	1930	Percentage control	Remarks
Paraffine oil 1%.....	18	13	3	599	6	99.15	Negligible injury
Red engine oil 1%.....	32	27	8	1515	33	98.15	Negligible injury
Emulso 2%.....	32	28	3	3297	10	99.74	Severe burning
Sunoco 1–40.....	7	7	0	1079	0	100.00	Negligible injury
Scalecide 1–25.....	29	26	6	2238	10	99.62	Negligible injury
Swan-Finch 1–40.....	11	9	0	1104	0	100.00	Severe injury
Kleenup 1–30.....	53	47	11	3681	17	99.61	Moderate injury
Dendrol 1–40.....	61	48	0	2468	0	100.00	Slight injury
Tar Distillate 1%.....	16	15	1	1552	1	99.95	Negligible injury
Tar Distillate 3%.....	18	16	0	1822	0	100.00	Slight injury
Kerosene emulsion 5%.	42	32	29	3350	624	84.16	Negligible injury

TABLE 2. RESULTS OF TREATMENTS AGAINST THE SPRUCE GALL APHID (*Adelges abietis*)

Treatment 1930	Number trees in plat	Number trees infested 1929	1930	Total galls 1929	1930	Percentage control	Remarks
Nicotine 1–800 Penetrol 1–200	18	16	2	1470	1	99.94	No injury
Nicotine 1–3200 Penetrol 1–200	17	15	10	2089	76	96.91	No injury
Nicotine 1–800 Fish oil soap 5 lbs.	28	27	8	2377	29	98.96	No injury
Nicotine 1–800 Laundry soap 5 lbs.	38	32	2	3867	3	99.93	No injury
Fish oil soap 5 lbs.	45	37	30	1608	595	68.54	No injury
Laundry soap 5 lbs.	39	32	19	3012	135	96.19	No injury
Lime-sulfur 1–40	16	14	0	1068	0	100.00	No injury
Lime-sulfur 1–8	13	12	0	1690	0	100.00	No injury
Derrisol (alone) 1–800	30	27	28	3215	1712	54.72	No injury
Check (untreated)	80	80	80	7509	8830		Unit increase = 1.176

MR. C. L. METCALF: Does the insect affect Colorado spruce?

MR. F. L. GAMBRELL: It is known to occur over most of the United States from the Pacific to the Atlantic Coast. I have observed it on Colorado spruce.

PRESIDENT FRANKLIN SHERMAN: We will now listen to a paper by F. F. Smith and F. W. Poos.

A COMPARISON OF THE FEEDING HABITS OF SOME SPECIES OF EMPOASCA

By F. F. SMITH and F. W. POOS, *Rosslyn, Va.*

(Withdrawn for publication elsewhere)

PRESIDENT FRANKLIN SHERMAN: The next paper is by F. W. Poos and F. F. Smith.

A COMPARISON OF OVIPOSITION AND NYMPHAL DEVELOPMENT OF *EMPOASCA FABAE* (HARRIS)[1] ON DIFFERENT HOST PLANTS

By F. W. POOS and FLOYD F. SMITH, *Division of Cereal and Forage Insect Investigations, U. S. Bureau of Entomology*[2]

ABSTRACT

During 1929 and 1930 certain forage crop and other plants were used in comparative tests to ascertain which plants *Empoasca fabae* chose for oviposition, and also the numbers of nymphs developing to the adult stage. With several of these host plants the amount of injury present seemed to be correlated in some way with the amount and type of the pubescence borne by these plants. In general, the rough hairy pubescent varieties within a species usually were much less injured by this leafhopper than the non-pubescent or appressed pubescent varieties. It was shown that more nymphs of *E. fabae* hatched from certain hosts than from others regardless of whether such hosts were very hairy or only slightly pubescent. In this study 101 tests were made involving the use of 3,562 adults and the hatching of 9,108 nymphs. Potato was apparently the preferred host plant among those tested, followed by Whippoorwill cowpea, dahlia, non-pubescent soybean (S. P. I. No. 55069), alfalfa, stringless greenpod bean, Dixie soybean, and red clover about in the order named. When varieties of red clover and soybean were tested, more nymphs of *E. fabae* hatched from the non-pubescent or appressed pubescent varieties which were used than from the rough hairy varieties. More nymphs hatched from Hairy Peruvian alfalfa than from Kansas alfalfa, a much less pubescent variety.

[1]Order Homoptera, family Cicadellidae.

[2]This paper reports on a part of a cooperative study of leafhopper injury to legumes by the U. S. Department of Agriculture between the Office of Forage Crops and Diseases, Bureau of Plant Industry, Dr. A. J. Pieters, acting in charge, and the Division of Cereal and Forage Insects, Bureau of Entomology, Dr. W. H. Larrimer, in charge. The authors gratefully acknowledge the assistance of Mr. J. W. Scrivener, Agent, and Mr. J. G. Conklin, Field Assistant, with details in these experiments.

The data obtained do not show that the rough hairy pubescence of certain varieties is the prime reason for their greater resistance to injury by *E. fabae*, since this leafhopper deposited eggs freely in all of the host plants tested even when the adult leafhoppers were confined to varieties of a single species of plant which bore the different types of pubescence. *E. fabae* developed from first-instar nymphs to adults readily on the varieties of alfalfa, red clover, and soybean which were used regardless of the amount and type of pubescence which was borne by these varieties. The comparison of the development of first-instar nymphs of *E. fabae* to adult upon different host plants was studied in 118 tests involving the use of 3,981 individuals. It seems probable that factors other than the amount and type of pubescence are at least in part responsible for the resistance to the injury by *E. fabae* observed in some of the strongly pubescent varieties.

During the course of studies on the disease-like injury which *Empoasca fabae* (Harris) causes to forage-crop legumes, it was apparent, as previously reported by several workers[3], that certain important varietal differences in withstanding attack by this leafhopper existed among the plants used in experimentation. For instance, the amount of injury present, especially in the case of alfalfa, red clover, and soybeans, seemed to be correlated in some way with the amount and type of pubescence borne by these varieties. That is, in general the rough hairy, strongly pubescent varieties usually were not seriously injured, whereas the non-pubescent or appressed pubescent varieties were usually considerably injured. Owing to this fact there naturally arose the question as to how the behavior and development of *E. fabae* were affected by the external physical characters of these and some of its other host plants; also, whether the theory that the pubescence of certain varieties protected them from the attack and consequent injury by this leafhopper was tenable. Accordingly, during the seasons of 1929 and 1930 a number of experiments were conducted at Arlington Experiment Farm (P. O. Rosslyn, Virginia), first, with the view of determining which plants *E. fabae* chose for oviposition; second, to compare the numbers of nymphs developing to the

[3]Hollowell, E. A., Monteith, Jr., John, and Flint, W. P. Leafhopper Injury to Clover. Phytopath. 17:399–404, illus. June, 1927.

Granovsky, A. A. Alfalfa "Yellow Top" and Leafhoppers. Jour. Econ. Ent. 21: 261–266. April, 1928.

Pieters, A. J. Red Clover's Hairiness in American Types is Due to the Leafhopper. Yearbook of U. S. Dept. of Agr. 1928: 521–524, illus. 1929.

Poos, F. W. Leafhopper Injury to Legumes. Jour. Econ. Ent. 22: 146–153, illus. February, 1929.

Jewett, H. H. Leafhopper Injury to Clover and Alfalfa. Ky. Agr. Expt. Sta. Bul. 293, March, 1929.

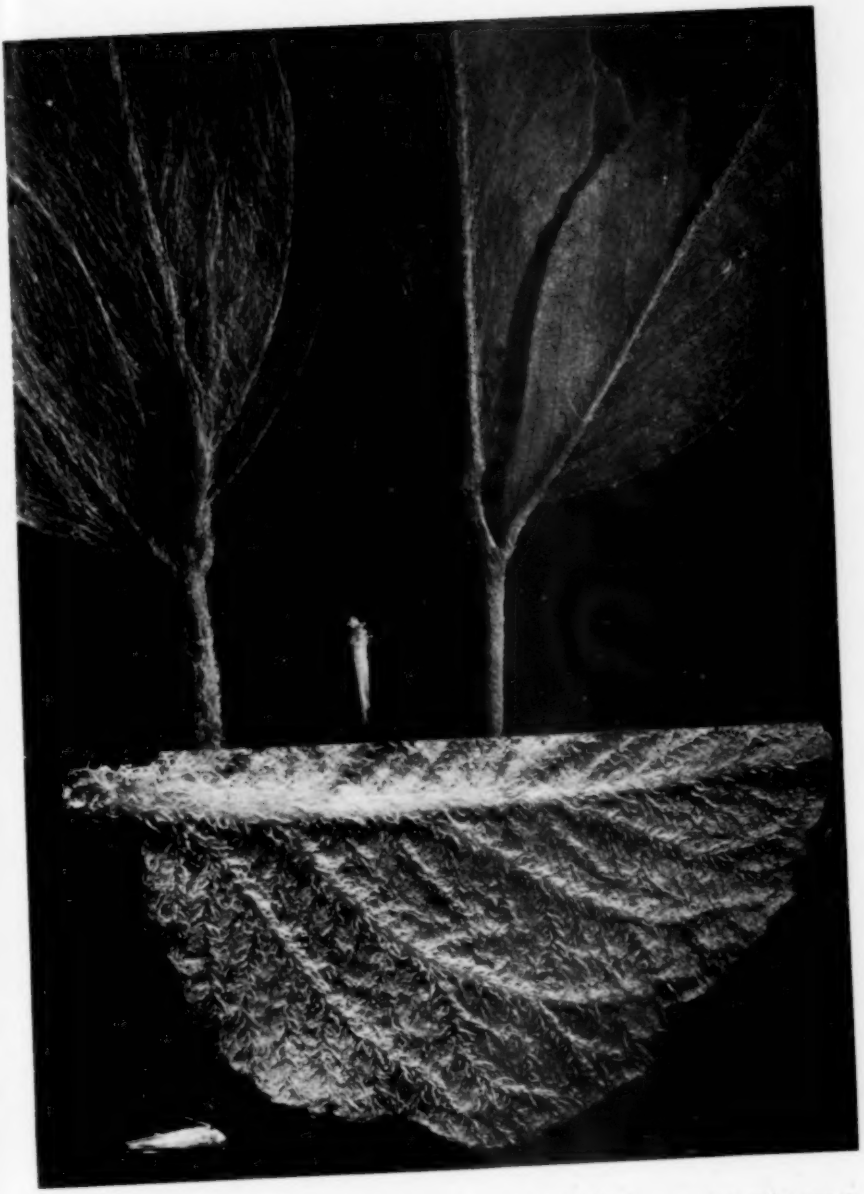
Monteith, Jr., John, and Hollowell, E. A. Pathological Symptoms in Legumes Caused by the Potato Leafhopper. Jour. Agr. Research 38: 649–677, illus. June, 1929.

adult stage; and third, to compare the amount of injury caused by these developing nymphs upon the various host plants used. All experiments referred to in this paper were carried on in a greenhouse that was shaded to an extent which prevented the maximum temperatures from rising higher than five degrees F. above those obtained in the outdoor insectary. All plants used in these experiments had passed the seedling stage and ranged from 6 to 30 inches in height. The adults of Empoasca which were used in these experiments were collected for the most part from potato plants at Arlington Farm. Internal genitalia of the males in these collections and of the male offspring of the females which were used in these experiments were examined in as great numbers as practicable in order to determine the identity of the species used. No males other than those of *E. fabae* were found among the offspring of the females used. During 1930 the genitalia of 256 male adults of Empoasca collected on potato in the field were examined for this purpose and of these only one specimen proved to be a species other than *fabae*.

Methods for Determining Choice of Host Plants for Oviposition. In comparing the choices for oviposition by adults of *E. fabae* in the different varieties of host plants, only those plants which were as near the same age, size, and stage of development as possible were selected for each test. An attempt was made to select an equal quantity of plant material of each variety for exposure to the adult leafhoppers under similar environmental conditions in each of the tests, in order to obtain dependable comparisons of the the responses of the insect. With some host plants, considerable variation in the results of individual tests was obtained. Tests were repeated several times, unless the first three tests, conducted independently, yielded similar results. During 1929 some of the tests with soybeans were made by placing one or two plants of each of two varieties, growing in small flowerpots, into soil in a bucket, both being then covered by the same glass cage which had its top covered with cheesecloth. The adult leafhoppers were then placed in the cage and allowed to feed and oviposit for a period of from one to five days, depending upon how much injury the insects produced. In cases where any parts of the plants which were suitable for the deposition of eggs became injured or abnormal during the time the plants were exposed to the adult leafhoppers and before the eggs had ample time to hatch, such tests were discarded because the ensuing results might have been unfair to the experiment in case the injured parts of the plants contained eggs which, therefore, could not have hatched. The leafhoppers were removed from the plants by fumigation and the latter were taken from the cage and placed upon the bench, the plants being separated sufficiently

to prevent the foliage of each from touching that of its neighbors. As the eggs hatched, the nymphs were removed from each plant daily and their numbers recorded in tabular form for each particular test. Larger plants, such as alfalfa, cowpea, stringless greenpod bean, certain clovers, and potato (and all host plants used during 1930) were exposed to adults in cages covered with cheesecloth, 2 feet by 2 feet by 2½ feet in size, which were located in the ground bed of the greenhouse. In most of the tests which were made during 1930 four flowerpots containing plants (two flowerpots containing plants of one variety and two containing plants of another) were used in each test and record was kept of the location of each flowerpot in each cage while the contained plants were being exposed to the adults for oviposition. The adult leafhoppers were introduced into the cage in a glass vial, 1 inch by 4 inches in size, placed in an upright position on the surface of the ground at equal distances from the host plants, after which the stopper was removed. Early in the work it was found that frequently more nymphs hatched from the plants located in the south half of the cage than from the plants located on the north side, probably owing to better light conditions on the south side which were favored by the adults. Therefore, one host plant of each variety used was always located in the south half of the cage in each test.

Choice of Host Plants for Oviposition. In Table 1 the results of 101 tests to determine the choice of host plants for oviposition by *E. abae* during 1929 and 1930 are summarized. In these tests a total of 3,562 adults were used and the hatching of 9,108 nymphs was recorded. It may be noted from the summary of data presented in Table 1 that apparently *E. fabae* has been correctly named the potato leafhopper, as more nymphs hatched from potatoes (Bliss Triumph, Irish cobbler, and Early Rose) in these experiments than from any other host plants with which they were compared. Whippoorwill cowpea and dahlia seemed to be next preferred, followed by the non-pubescent soybean (S. P. I. No. 55069) alfalfa, stringless greenpod bean, Dixie soybean, and red clover, about in the order named. The importance of the presence of potatoes in influencing the abundance of the potato leafhopper in a given area was apparently well illustrated during the latter part of July, 1930, in central Wisconsin, where observations showed this leafhopper generally abundant and injuring potatoes and alfalfa considerably; whereas in the southeastern part of the State, where the potato acreage was much less concentrated, the injury to these crops by this leafhopper was not of great importance. It is realized that many other factors may have contributed to bring about this condition, especially those of the soil and climate.

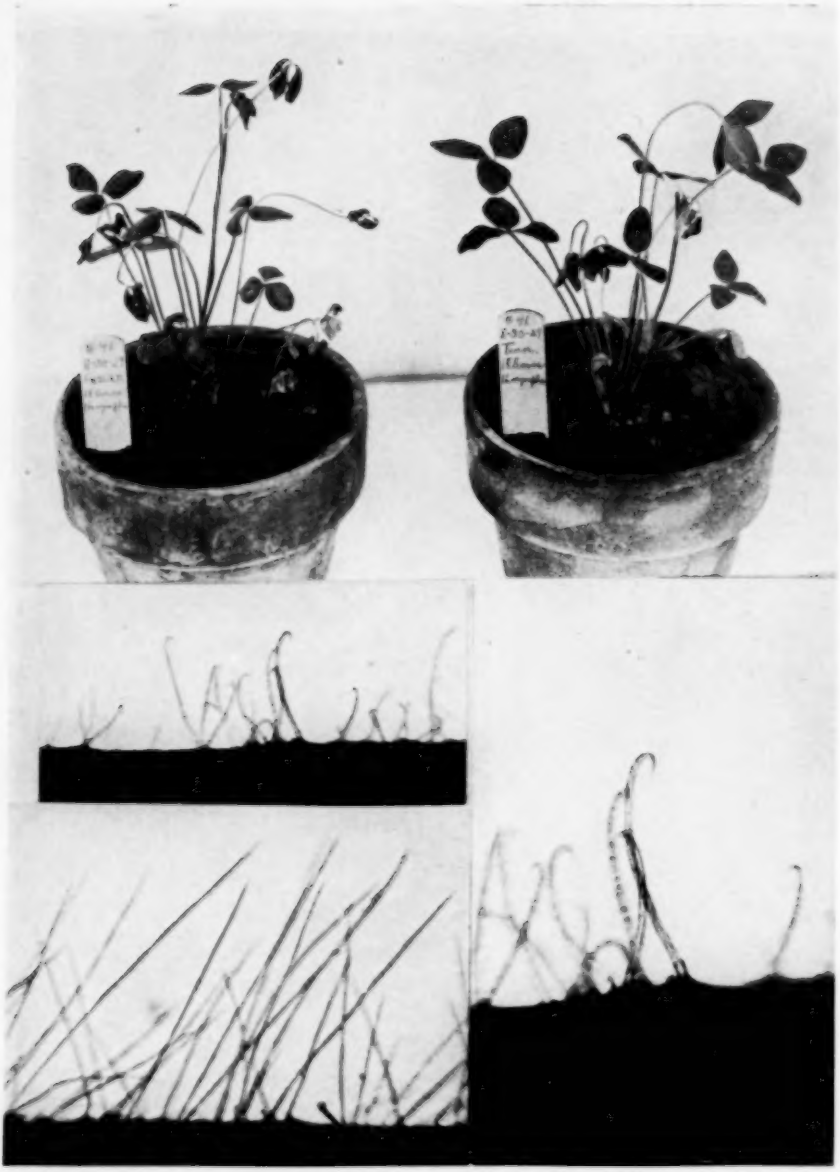


A

B

A.—Left, Hairy Peruvian alfalfa; right, Kansas alfalfa. To compare pubescence. Below, adult *Empoasca fabae* (Harris). 6x.

B.—Lower surface of small potato leaf showing pubescence as compared with adult of *E. fabae* (Harris). About 5½x.



A.—Russian red clover, left; Tennessee red clover, right. Plants selected to compare nymphal development and to compare injury resulting from these developing nymphs.

B.—Tangential view of hairs on petiole of stringless greenpod bean. 50x.

C.—Same as B. 100x.

D.—Tangential view of hairs on petiole of Michigan red clover. 50x.

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TABLE 1. CHOICE OF HOST PLANTS FOR OVIPOSITION BY *Empoasca fabae* (HARRIS). SUMMARY OF TESTS AT ARLINGTON EXPERIMENT FARM, 1929 AND 1930

Host Plants Compared		Year	Number of tests	Total adults used	Total nymphs hatched		Percentage of total nymphs hatching	
A.	B.				A.	B.	A.	B.
Early Rose Potato	Kansas Alfalfa	1929	4	220	975	366	75.9	24.1
		1930	3	160	627	143		
Bliss Triumph Potato	Whippoorwill Cowpea	1930	3	135	301	235	56.2	43.8
Early Rose Potato	Dahlia[1]	1930	5	280	481	267	64.3	35.7
Irish Cobbler Potato	Stringless Greenpod Bean	1930	3	157	945	208	82.0	18.0
Irish Cobbler Potato	Non-pubescent Soybean[2]	1930	3	140	387	132	74.6	25.4
Whippoorwill Cowpea	Stringless Greenpod Bean	1929	6	180	260	217	55.5	44.5
		1930	3	130	111	80		
Kansas Alfalfa	Hairy Peruvian Alfalfa	1929	6	370	281	478	39.5	60.5
		1930	7	295	254	343		
Kansas Alfalfa	Stringless Greenpod Bean	1930	2	120	57	43	57.0	43.0
Kansas Alfalfa	Russian Red Clover	1930	2	30	84	20	80.8	19.2
Non-pubescent[2] Soybean	Herman Soybean	1929	4	159	67	27	82.3	17.7
		1930	3	110	160	22		
Non-pubescent[2] Soybean	Dixie Soybean	1929	6	105	179	96	65.3	34.7
		1930	3	90	177	93		
Dixie Soybean	Herman Soybean	1929	2	26	20	7	78.6	21.4
		1930	3	140	94	24		
Non-pubescent[2] Soybean	Stringless Greenpod Bean	1930	3	110	148	38	79.6	20.4
Hairy Peruvian Alfalfa	Tennessee Red Clover	1930	3	85	119	19	86.2	13.8
Red Clover (Foreign)[3]	Red Clover (Native)[4]	1929	9	105	51	55	61.2	38.8
		1930	18	415	269	148		
Totals		1929–30	101	3562		9108		

[1]Pat O'Mara, Cigarette, and Jersey Beauty.
[2]S.P.I. No. 55069. [3]Russian, Italian, French. [4]Tennessee and Michigan.

Plate 11, B, illustrates the pubescence of a small potato leaf compared with the adult of the potato leafhopper, both enlarged to the same scale. The hairiness does not prevent this plant from being the most popular host plant of this leafhopper. It is probably chosen because it is usually relatively more succulent than other hosts available, and possibly because of chemical or other factors involved.

It is not the object of this paper to show what significance the different types and degrees of hairiness of plants have upon the various phases of the behavior and development of the potato leafhopper but merely to present the data obtained, which apparently indicate that pubescence (amount and type) is not the prime factor in determining the choice of host plants for oviposition by adults of *E. fabae*. Much additional work will be necessary to determine the exact significance which the pubes-

cence upon host plants of *E. fabae* bears to the various phases of the behavior and development of this insect. According to the data obtained, this species deposited eggs freely in all the host plants used even when it was confined to varieties of a single species of plant which had the different types and amounts of pubescence. It is realized that in considering the relationship between the pubescence of the host plants and the behavior of the insect only varieties of the same species can be used, although there is sometimes more difference in the hairiness between varieties of a species than is found between two different species in other cases.

According to the summary of data presented in Table 1, more nymphs, or 60.5 per cent of the total, hatched from Hairy Peruvian alfalfa than from the less pubescent Kansas alfalfa (Plate 11, A), when both varieties were exposed to the same number of adults of *E. fabae* for oviposition. There was considerable variation in the results of the individual tests; however, when the mean difference of the individual tests was calculated it was found to be statistically significant. It should be noted how closely, except in the case of red clover, the summarized results of 1929 agreed with the summarized results of 1930, when the experiments were repeated. In 1929, 51.9 per cent of the total number of nymphs hatching from red clover were from the native red clover Tennessee and Michigan, when these varieties were compared with the foreign Russian red clover, a variety having appressed pubescence. During 1930 only 35.5 per cent of the nymphs hatched from the same varieties of native red clover—which bear rough hairy pubescence. As in the case of the tests with alfalfa, the variation in the results of the individual tests was considerable and the mean difference obtained was also found to be statistically significant. The conclusion that the amount and type of pubescence on these varieties of red clover were responsible for this difference in the number of nymphs of *E. fabae* which hatched from these varieties should, for the present, be held in abeyance.

Owing to the unusual drought conditions and the prevalence of mosaic, much difficulty was experienced in obtaining what appeared to be normal red clover plants for the experiments during 1930. The plants used in several tests were discarded before these tests were completed because of abnormal development. In some cases soon after the population of *E. fabae* was placed on the plants for oviposition, the external symptoms of mosaic developed with seemingly abnormal rapidity where a short time previously they had not been evident. A test in which zigzag clover, *Trifolium medium*, which is a slightly pubescent clover, was compared with a foreign variety having appressed pubescence, and in

which each of these plants was exposed to 23 adults of *E. fabae*, yielded a total of 224 nymphs of which 157, or 70 per cent, hatched from the foreign red clover.

According to Table 1 there hatched from the non-pubescent soybean, (S. P. I. No. 55069) 65.3 per cent and 82.3 per cent of the total nymphs when compared with the Dixie and Herman varieties respectively. Statistically this difference was significant but it is still questionable, in the minds of the writers, whether the lack of pubescence was the determining factor in the choice of this variety for the deposition of eggs by *E. fabae* when this leafhopper was offered a choice of these varieties. Field observations on small plantings of several lots of soybeans at Arlington Experiment Farm during 1930 indicated that some of the other non-pubescent lots were apparently much less susceptible to Empoasca injury than was No. 55069. General observations during the seasons of 1928, 1929, and 1930, among the large numbers of plantings of hairy varieties of soybeans in several localities, indicated that the potato leafhopper was no more abundant on the less hairy varieties than on the most pubescent ones. Field observations upon various plantings of varieties of alfalfa and red clover during the same years have not revealed any noticeable difference in the abundance of this leafhopper on these plantings when they had received similar cultural treatment.

During 1929 four tests, not included in the summary given in Table 1, were made in which adults of *E. fabae* were given a choice of all three varieties of soybeans referred to above. Out of a total of 108 nymphs, 56, 30, and 22 hatched from the non-pubescent, Dixie, and Herman varieties, respectively. Similarly when eleven tests with non-pubescent soybean, Herman soybean, and Whippoorwill cowpea were used, 211, 182, and 371 nymphs hatched from these host plants, respectively. These plants were comparatively young and very succulent yet the pubescence on the Herman variety was well developed.

METHODS OF COMPARING NYMPHAL DEVELOPMENT. Nymphs, in the first instar, were placed upon potted plants, or upon plants growing in the ground bed of the greenhouse, which were enclosed in cheesecloth cages. An attempt was made to place no more nymphs on each plant than could be carried through to maturity without seriously injuring the plant. Plants of different varieties of clover, alfalfa, and soybean were selected which matched one another with regard to age, size, color, and extent of plant growth, especially leafiness. (Plate 12, A.) Records of nymphal development were also made on individual plants of potato, Whippoorwill cowpea, stringless greenpod bean, etc., at the same time.

The size of each plant was recorded at the time the nymphs were placed upon it. The nymphs, about 1 mm. in length, were handled with a small camel's-hair brush and all nymphs which were not able to walk about readily after being transferred, thus demonstrating that they were uninjured by handling, were killed and discarded from the experiment. When the nymphs reached the adult stage the date and the number of individuals developing to maturity were recorded. In some tests it was necessary to close the experiments when the nymphs had reached the fourth or fifth instar but no difference was noted in the percentage of development recorded, when this procedure was followed, probably owing to the fact that after reaching the fourth instar the nymphs had passed the most hazardous stages of their development.

COMPARISON OF NYMPHAL DEVELOPMENT. In Table 2 are summarized the results of 118 tests during 1929 and 1930 involving the use of a total of 3,981 nymphs of *E. fabae* for comparison of development to adult upon different host plants when the nymphs were placed upon the plants in the early part of the first instar of their development. These data are not presented as a definite determination of the number of nymphs which may be expected to develop to adults on these particular host plants, but merely to show the number of nymphs which hatched in these experiments. It may be noted from Table 2 that the highest percentage of development of nymphs to adults obtained during 1930 was 90.7; these nymphs developed on Hairy Peruvian alfalfa. Potato, Whippoorwill cowpea, Kansas alfalfa, non-pubescent soybean, Russian red clover, Tennessee red clover, white clover (a strain comparatively resistant to injury by *E. fabae*), Dixie soybean, Herman soybean, Michigan red clover, stringless greenpod bean, and zigzag clover followed in the order named, ranging from 81.7 per cent to 17.7 per cent. These data show that the amount and type of pubescence on the different species and varieties of plants used in these studies are not inversely proportional to the number of nymphs of *E. fabae* which developed to adults on these host plants.

During both 1929 and 1930 more nymphs developed to adults upon Hairy Peruvian alfalfa than upon Kansas alfalfa which is less pubescent. (Plate 11 B.). Pieters[4] considers the development of the hairiness in American types of red clover as probably being due to *E. fabae*. While it is true that the rough hairy American types of red clover are much more resistant to injury by *E. fabae* than are the appressed pubescent

[4]Pieters, A. J. Red Clover's Hairiness in American Types is Due to Leafhopper. Yearbook of U. S. Dept. of Agr., 1928: 521–524, illus.

TABLE 2. NYMPHAL DEVELOPMENT OF *Empoasca fabae* (HARRIS) ON DIFFERENT HOST PLANTS AT ARLINGTON EXPERIMENT FARM

Summary for 1929 and 1930

Host Plant	Year	Number of tests	Total nymphs used	Total developed to adults	Percentage developed to adults	
Kansas Alfalfa	1929	4	404	218	53.9	60.3
	1930	3	150	116	77.3	
Hairy Peruvian Alfalfa	1929	4	404	226	55.9	65.3
	1930	3	150	136	90.7	
Russian Red Clover	1929	15	405	155	38.3	43.9
	1930	7	105	69	65.7	
Michigan Red Clover	1929	6	282	57	20.2	27.4
	1930	6	90	45	50.0	
Tennessee Red Clover	1929	9	92	58	63.0	60.4
	1930	5	85	49	57.6	
Non-pubescent Soybean[1]	1929	4	180	35	19.4	51.0
	1930	13	265	192	72.4	
Dixie Soybean	1929	1	30	9	30.0	52.8
	1930	8	180	102	56.7	
Herman Soybean	1929	4	114	15	13.2	35.4
	1930	8	160	82	51.2	
Whippoorwill Cowpea	1930	4	210	170	80.9	
Potato	1930	4	240	196	81.7	
Stringless Greenpod Bean	1930	5	225	83	36.9	
Zigzag Clover[2]	1930	3	175	31	17.7	
White Clover	1930	2	35	20	57.1	
Total	1929–30	118	3,981	2,064	51.8	

[1]S.P.I. No. 55069. [2]*Trifolium medium.*

foreign types, the results of our studies indicate that *E. fabae* develops from first-instar nymphs to adults readily on both types of red clover. During 1929 and 1930, 60.4 per cent nymphal development was obtained on Tennessee red clover as compared with 27.4 per cent and 43.9 per cent on Michigan red clover and Russian red clover, respectively, the latter bearing the appressed type of pubescence. Thus it appears that the rough hairy pubescence was not the principal factor in determining the percentage of nymphs which developed to adults, although this external physical characteristic may possibly be correlated with one or more other factors which may be responsible for a certain degree of resistance to this insect and its injury. Therefore it still seems quite possible that *E. fabae* has been an important contributing factor in the

development of the American types of red clover which bear a rough hairy pubescence and are much more resistant to injury by *E. fabae* than are the varieties of foreign red clover. Only 17.7 per cent of the nymphs placed upon zigzag clover, *Trifolium medium*, developed to adults. This clover is only slightly hairy and the explanation for the low percentage of development apparently must be based upon factors other than its pubescence.

During 1930 nymphal development was much higher on non-pubescent soybean (72.4 per cent) than on Dixie soybean (56.7 per cent) or on Herman soybean (51.2 per cent). The total recorded as developing to adult on the non-pubescent variety during 1929 (19.4 per cent) is probably too low owing to the fact that in some tests more nymphs were placed on the plants than could be carried through to maturity before the plants were seriously injured; a part of the nymphs, therefore, probably died and were lost to the experiment. An interesting fact recorded in connection with these experiments was that frequently some of the nymphs of *E. fabae* developed to the adult stage on soybeans one or two days earlier on the non-pubescent variety than on the Dixie or Herman varieties. Owing to the difference in the percentage of nymphs developing on the Dixie and Herman varieties of soybean, both of which bear rough hairy pubescence, it seems possible that non-pubescent varieties would also differ considerably in the percentage of nymphs developing to adults on them. As in red clover, the pubescent varieties of soybeans used were much more resistant to injury by *E. fabae* than the non-pubescent variety used in our tests. As referred to under "Choice of Host Plants for Oviposition," field observations during 1930 indicate that it may be entirely possible to obtain a non-pubescent variety of soybean which is as resistant to injury by *E. fabae* as are any of the pubescent varieties.

Only 36.9 per cent of the nymphs placed upon stringless greenpod bean developed to adults in our tests. Many nymphs were found dead and attached to the plants by the sharply pointed hooks located at the distal end of the tiny hairs. (Plate 12, B and C.) It is well known how extremely active the nymphs of *E. fabae* are and how rapidly they race over the surface of their host plants, running sidewise even more rapidly than forward or backward. This habit is probably responsible for the loss of many *E. fabae* when they become entangled in the hooked hairs of the stringless greenpod bean. Young nymphs of *E. fabae* were frequently observed to be impaled on the hooked hairs of this host plant. This was not observed on any of the other host plants used, none of which had hairs with terminal hooks. (Plate 12, D.)

INJURY TO HOST PLANTS BY DEVELOPING NYMPHS. During 1929 the injury caused by developing nymphs to some varieties of alfalfa and red clover was compared by selecting plants of different varieties which matched one another with regard to size, color, and extent of plant growth. The total number of leaves or leaflets on each plant was recorded when the nymphs were placed on them and the number of leaves injured by these insects at the time they reached maturity was recorded. No differences in the amount of injury caused to Kansas alfalfa and to Hairy Peruvian alfalfa were noted. The results of tests with red clover are tabulated on a comparable basis as follows:

Red clover variety	Number of tests	Total number of— Nymphs placed upon plants	Leaves upon plants	Nymphs per leaf placed upon plants	Per cent of— Total nymphs matured	Total leaves injured
Michigan	6	282	362	0.78	20.2	31.5
Russian	13	389	649	.60	36.7	52.5
Tennessee	7	57	78	.73	70.2	50.0

It may be noted from these data that Russian red clover had a greater percentage of leaves injured (Plate 12, A) than either of the other two varieties used, although a smaller number of nymphs per leaf was placed upon it. The number of nymphs maturing to adult (36.7 per cent) was also less than for the Tennessee variety (70.2 per cent). The latter figure, however, was based on only 57 nymphs, which is not considered a sufficient number for a fair comparison. (See Table 2 for summary of data on this point.)

The fallacy in trying to determine by this method the relative amount of injury caused by developing nymphs lies in the fact that the number and stage of development of nymphs on each plant can not be recorded at frequent intervals. An additional difficulty in such a study is encountered by the fact that a varying period of time must elapse before the complete effect of the injury caused by the feeding of *E. fabae* becomes evident through the appearance of external symptoms. Other variable factors, such as temperature, humidity, and soil moisture which enter into the results when a large number of experiments are to be made comparable, were not made constant. This work was not continued during 1930 because of the lack of proper facilities for making accurate comparisons of the injury caused by developing nymphs to their various host plants.

PRESIDENT FRANKLIN SHERMAN: The next paper will be presented by G. T. Bottger and V. F. Kent.

SEASONAL-HISTORY STUDIES ON THE EUROPEAN CORN BORER IN MICHIGAN

By G. T. Bottger and V. F. Kent, *U. S. Bureau of Entomology*

Abstract

Observations made on several hundred specimens for five consecutive seasons, both in the field and in the insectary, indicate that favorable temperatures and humidity are the most influential factors in promoting normal seasonal development of the European corn borer (*Pyrausta nubilalis* Hübn.)[1] All stages of development are either hastened with an excess of heat, as in the seasons of 1929 and 1930, or are retarded with a preponderance of low temperatures, as in the seasons of 1926 and 1927. High humidity caused by heavy precipitation or an accumulation of moisture from other sources is indispensable to the insects' development.

The average date for the beginning of pupation in the field was June 9; and that for the beginning of adult emergence, June 22. The average date for the beginning of oviposition was June 25; that for maximum oviposition, about July 10, and practically no eggs were laid after July 26.

In view of the fact that a knowledge of the times of the first seasonal appearance, maximum occurrence, and last records of the different stages of the corn borer are so extremely important to the progress of control measures, considerable emphasis has been placed on obtaining accurate and comprehensive data on the seasonal history of this insect at the Monroe, Michigan, field laboratory.

Field examinations of a definite number of specimens, supplemented by observations on several hundred specimens kept under insectary conditions, have been made at regular intervals during the seasonal development of this insect for the seasons 1926 to 1930, inclusive.

Field Conditions. Pupation. During the seasons of 1926 and 1927 as many larvae were collected as was possible in the time allowed for this work, in order to determine for each season the average date for the first larvae to pupate, for maximum pupation, and for the last larva to pupate. During the seasons of 1928, 1929, and 1930 collections of 100 specimens were made at regular intervals which began not later than May 20 and extended throughout the period of seasonal development.

Collections of larvae for these observations were all made in Monroe County from corn débris left on the surface of the soil after farm operations had been completed. In the years 1929 and 1930, counts were made both in fields sown to oats where the débris was partially shaded and in fields where the débris was practically all exposed to the sun,

[1]All determinations of major importance were made by Dr. Philip Luginbill, entomologist in charge of the laboratory at Monroe, Michigan. The writers are indebted for assistance from Mr. A. I. Balzer, formerly of the same laboratory, in conducting these investigations.

but the results were so nearly the same that it was not deemed necessary to distinguish between the two records in this paper.

Results of pupation studies for the five-year period appear in Table 1.

TABLE 1. AVERAGE DATES OF PUPATION OF THE EUROPEAN CORN BORER, MONROE, MICH., 1926–1930

	1926	1927	1928	1929	1930	Average
Date of first pupa	June 16	June 14	June 11	June 3	June 3	June 9
Date of maximum pupation	———	June 21	June 22	June 19	June 15	June 19
Date of last larva	———	June 27	July 11	July 6	July 3	July 4

It will be seen that the beginning of pupation takes place about June 9, that maximum pupation occurs about June 19, and that 100 per cent of the larvae have pupated by July 4.

EMERGENCE. Collections of specimens for the purpose of obtaining data on emergence were continued in the same locations and in the same numbers and manner as were made for the studies on pupation. The number of empty pupal cases was considered representative of the number of moths which had emerged. The data obtained are summed up in Table 2.

TABLE 2. AVERAGE DATES OF EMERGENCE OF ADULTS OF THE EUROPEAN CORN BORER, MONROE, MICH., 1926 TO 1930

	1926	1927	1928	1929	1930	Average
Date of first adult	July 1	June 23	June 22	June 20	June 15	June 22
Date of maximum emergence	———	———	July 11	July 1	June 29	July 4
Date last pupa was taken	———	———	July 17	July 16	July 7	July 13

These data indicate, on the average, that moths begin to emerge about June 22, that emergence reaches its maximum around July 4, and that emergence is practically completed by July 13.

It may be stated that pupal mortality was 9 per cent in 1927, 8 per cent in 1928, and 15 per cent in 1930.

OVIPOSITION. Immediately after finding the first empty pupal case, which marks the beginning of adult emergence, several hundred corn plants were examined each season until the first egg mass was found. After oviposition was definitely known to be in progress a specified number of plants, the number ranging from 200 to 500, were examined at 3-day intervals as long as any eggs could be found. The egg masses were removed from the plants at the time they were found, and taken to the laboratory, where they were counted. The results of these observations appear in Table 3.

TABLE 3. SUMMARY OF OVIPOSITION RECORDS OF EUROPEAN CORN BORER MOTHS TAKEN IN THE FIELD

	1926	1927	1928	1929	1930	Average
First eggs observed	July 2	June 24	July 1	June 20	June 17	June 25
Date of maximum oviposition	———	July 14	July 10	July 9	July 7	July 10
Last eggs found	———	July 31	July 23	Aug. 1	July 17	July 26

It appears from the foregoing figures that the average date for the beginning of oviposition in the vicinity of Monroe is about June 25, that maximum oviposition occurs about July 10, and that practically no eggs are laid after July 26.

The average number of eggs per mass in 500 masses carefully counted during each season has consistently been 17.

WEATHER RECORDS. As meteorological observers at Monroe for the Weather Bureau, the writers have available a complete record for the years 1926 to 1930, inclusive, of weather conditions within 5 to 10 miles of the places where the observations on seasonal development

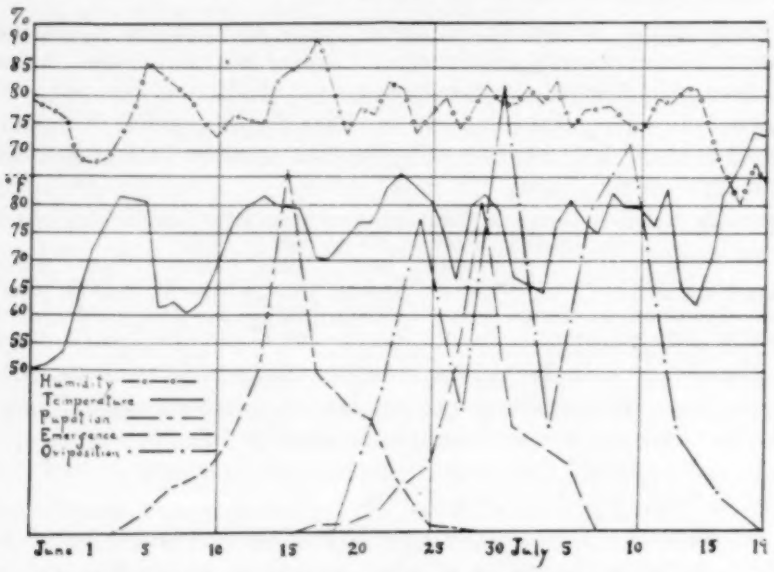

FIG. 21.—Graph illustrating influence of weather on pupation, emergence, and oviposition of the European corn borer under field conditions, in 1930

in the field were made. Maximum and minimum thermometers and a hygrothermograph kept in a standard weather shelter were regularly observed for data on the temperature and on humidity. A thermograph was kept in the insectary to furnish accurate data on temperature for all experiments conducted there.

During the season of 1930, 100 specimens were examined at 2-day intervals during pupation and emergence, and 450 plants were examined for eggs at 3-day intervals during the time of oviposition. These counts were made in order to determine the influence of weather on the seasonal development of the corn borer, as is illustrated in the graph, Figure 21.

The seasonal development curves are superimposed upon a graph indicating the daily mean temperatures and humidity.

Pupation is apparently dependent on daily mean temperatures not lower than 65° to 70° F. and increases as the temperature rises, provided there is sufficient humidity.

Emergence is hastened by warm weather and high humidity, and is retarded by a noticeable drop in temperature.

Oviposition occurs only on nights when the temperature is high enough for the moths to be active. The greatest number of eggs were taken on days following evening temperatures ranging from 75° to 80° at 10 p. m., the hour when activity is believed to be most common.

Tendency Toward A Second Generation. Dissections of 500 green corn plants during the month of August, 1930, yielded 3 empty pupal cases. This observation is conclusive evidence of the emergence of second-brood moths, and a tendency of the insect toward producing two generations per year in this area.

Rearing Under Insectary Conditions. The laboratory rearing was all done in a small, closed room at the east end of the insectary. This room has two windows (2 feet by 5 feet in size) which were kept open during the entire period of seasonal development, thus making the conditions within correspond very favorably with those outside. Although the fluctuation was less than in the field, the average mean temperatures were practically the same.

The specimens used for rearing were larvae collected from corn débris in fields within a 10-mile radius of Monroe, during the months of March and April of each season.

Only healthy larvae were selected and isolated for pupation and emergence, and after May 1 these specimens were observed daily until they completed their life cycle. An individual record was kept of each specimen. Several different types of receptacle, or pupation chamber, were used, in order to determine the most satisfactory kind for this purpose. The best results were obtained by isolating the larvae in ½-inch by 2-inch shell glass vials with strips of blotting paper to hold moisture, and stoppered with copper-screen caps. These vials were kept in trays made of ¼-inch white pine with beaver-board bottoms, and which had capacities of 200 vials each.

Moisture was artificially supplied by means of a fine spray, made with a hand pump of the atomizer type.

Tables 4 and 5 briefly summarize the data on pupation and adult emergence under insectary conditions.

TABLE 4. DATA ON PUPATION OF THE EUROPEAN CORN BORER UNDER INSECTARY CONDITIONS

	1926	1927	1928	1929	1930	Average
Date of first pupa	June 16	May 25	June 9	June 4	May 26	June 4
Date of maximum pupation	June 26	June 24	July 2	July 6	June 24	June 28
Date of last larva	July 13	July 23	Aug. 27	Sept. 6	Aug. 16	Aug. 11
Number of larvae used	71	822	572	1,000	1,161	

TABLE 5. DATA ON EMERGENCE OF THE EUROPEAN CORN BORER UNDER INSECTARY CONDITIONS

	1926	1927	1928	1929	1930	Average
Date of first adult	July 3	June 22	June 28	June 23	June 17	June 25
Date of maximum emergence	July 8	July 9	July 14	July 20	July 8	July 12
Date of last pupa	July 20	Aug. 7	Sept. 14	Sept. 3	Aug. 30	Aug. 21
Number of larvae used	71	822	572	1,000	1,161	

These tables show that seasonal development in the insectary lags behind the development in the field. This lagging is believed to be due to inadequate moisture, and to the slightly retarded temperatures which are prevalent in the insectary during the early part of the season. Mating and oviposition cages were started in each season after the first well developed male and female had emerged. Each female moth was mated with one or two males.

The mating and oviposition cages which appeared to be the most satisfactory to the writers were made by removing the ends of 1-quart, cylindrical, ice-cream containers, and attaching copper screen wire to them with paraffin. One end of each container was equipped with a removable lid, to the outside of which the screen wire was attached, and which provided a means of placing new moths in the cage and removing dead moths, as well as a means of removing the eggs. In the bottom of each container was placed a round piece of blotting paper just small enough to slide through the cylinder; it was kept moist with a sugar solution to provide the moths with both food and moisture. Inside of the cages, lining the walls, were placed sheets of white typewriting paper on which the moths could oviposit.

Observations of these cages were made daily, and the paper was removed whenever the moths had oviposited on it and replaced with new paper. The eggs were counted with the aid of a binocular microscope, and placed on blotting paper in shallow trays which were kept moist by applying a little water daily. After the eggs had hatched the infertile eggs (those in which the embryos developed but failed to hatch) and those which hatched were separately counted.

Mating and oviposition cages were started at frequent intervals throughout the season in order to obtain data on moths emerging at all possible times. The length of incubation period, percentage of infertile

eggs, percentage of eggs hatched, and percentage of eggs failing to hatch were all based on the total number of eggs deposited by each moth, regardless of whether the eggs were deposited on the screen ends or elsewhere. When the location of the egg masses demanded it the cages were destroyed and the moths were removed to new cages in order that the eggs might be removed for counting. Table 6 summarizes the observations made.

For obtaining the data in the foregoing table, from 30 to 50 moths were used during each season with the exception of 1926, when only 14 moths were available. The average number of eggs per mass ranged from 21.2 to 24.86, with an average of 23.04 for the five-year period.

LONGEVITY OF MOTHS IN THE INSECTARY. In each season a specified number of moths were segregated in cages and subjected to different conditions, some being isolated with food but allowed to copulate naturally, and some restrained from copulation while with food, and others without food; separate records were made of the length of life of the males and of the females in each class. In Table 7 is presented a summary of the results.

CONDITIONS IN FIELD CAGES. During the seasons of 1928, 1929, and 1930, pupation and emergence counts were made from corn fodder in the conservation cages located in Monroe County which are maintained by the Bureau of Entomology. These cages are approximately 100 feet square and 9 feet high, constructed of wooden frames, and covered with copper wire screen, which affords considerable protection from the elements. The corn in these cages was set up in shocks, and the specimens used for observation were taken from the interior of the shocks. Results of the counts are presented in Tables 8 and 9.

TABLE 8. DATA ON PUPATION OF THE EUROPEAN CORN BORER

	1928	1929	1930	Average
Date of first pupation	June 20	June 10	June 6	June 12
Date of maximum pupation	July 3	June 19	June 23	June 25
Date of last larva	Aug. 22	July 25	June 29	July 25
Number of days pupation lasted	72	51	23	49

TABLE 9. DATA ON ADULT EMERGENCE OF THE EUROPEAN CORN BORER IN FIELD CAGES

	1928	1929	1930	Average
Date of first adult	July 3	June 26	June 19	June 26
Date of maximum emergence	July 11	July 9	July 4	July 8
Date of last pupa	Aug. 22.	Aug. 6	Aug. 13	Aug. 3
Number days pupation lasted	50	40	24	38

Pupal mortality in the cage in 1930 was 5 per cent. In the field it was 15 per cent. It is believed that the protection from the intense heat of

TABLE 6. SUMMARY OF OBSERVATIONS OF EGGS OF EUROPEAN CORN BORER MOTHS LAID IN OVIPOSITION CAGES

Year	Average preoviposition period (days)	Average oviposition period (days)	Average postoviposition period (days)	Average number of eggs laid per moth	Maximum number of eggs laid per season	Minimum number of eggs laid per season	Percentage of eggs hatched	Percentage of infertile eggs	Percentage failed to hatch	Average length of incubation period (days)
1926.....	3.1	6.	2.2	441.	1,061	64	89.8	——	——	6.28
1927.....	3.22	6.85	1.61	401.7	869	6	88.25	4.32	7.42	6.1
1928.....	2.7	6.63	2.3	337.6	774	11	89.50	2.99	7.51	5.97
1929.....	5.07	8.08		397.	965	5	87.71	8.59	3.7	6.48
1930.....	3.9	8.06	2.38	411.1	1,309	16	94.21	4.23	1.54	5.67
Average .	3.598	7.12	2.12	397.68	——	——	89.89	5.032	5.042	6.10

TABLE 7. DATA ON LONGEVITY OF MALE AND FEMALE MOTHS OF THE EUROPEAN CORN BORER

	With copulation				Without copulation							
	With food				With food				Without food			
Year	Number of males used	Length of life of males (days)	Number of females used	Length of life of females (days)	Number of males used	Length of life of males (days)	Number of females used	Length of life of females (days)	Number of males used	Length of life of males (days)	Number of females used	Length of life of females (days)
1926....	7	12.3	12	11.7	7	5.6	6	4.3	–	—	—	—
1927....	21	11.9	43	11.4	—	—	—	—	–	—	—	—
1928....	7	9.	32	10.6	26	12.2	9	13.2	–	—	—	—
1929....	40	12.4	40	15.6	–	—	–	—	10	16.1	15	24
1930....	80	11.4	40	14.2	8	7.8	–	—	8	4.8	—	—
Average	—	11.4	—	12.7	–	8.5	–	—	–	—	—	—

the sun and from the drying effect of the winds during the month of June were responsible for the lesser mortality in the cage; however, the shelter afforded by the cage earlier in the season seemed to retard the seasonal development of the insect, causing many specimens in the different stages to vary in their time of development.

Summary

The earliest date pupae have been found in the field in the Monroe area is June 3, and the average date of beginning of pupation for the five-year period is June 9.

Maximum pupation has occurred between June 15 and June 22 throughout the four years from 1927 to 1930, inclusive, the average date falling on June 19.

The earliest recorded date for emergence is June 15, in 1930, and the average of the earliest recorded dates for each of five consecutive years is June 22.

Maximum emergence ranged in date from July 11, in 1928, to as early as June 29, in 1930, the average date of maximum emergence for the five years being July 4.

Eggs have been found in the field as early as June 17, in 1930, and maximum oviposition has been found to occur about July 10. Oviposition is practically complete by July 26.

Normal seasonal development is dependent upon high temperatures accompanied by an abundance of moisture, and where either of these factors is rendered abnormal, by either natural or artificial means, the seasonal development of the insect is likewise abnormal.

Both pupation and emergence were delayed under conditions prevailing in the insectary and the cages.

The average length of life for a female moth, when allowed to feed and copulate, is about 13 days, or about one day longer than the average for males.

The average number of eggs laid per moth in the insectary was 397.7, and there was an average of 23 eggs per mass, or about 6 eggs per mass more than the average in the field.

There appears to be a tendency of *Pyrausta nubilalis* to produce two generations per year in Michigan.

President Franklin Sherman: The next paper is by G. A. Fitch.

SOME OBSERVATIONS ON THE PLANTING DATE OF CORN AND ITS RELATION TO EUROPEAN CORN BORER POPULATION

By G. A. FICHT, *Purdue University Agricultural Experiment Station*

ABSTRACT

This paper is a report of some of the progress made on three seasons of study pertaining to the relation of the planting date of corn to corn borer (*Pyrausta nubilalis* Hübn.) infestations and populations. Other conditions being equal, greatly reduced infestations and subsequent borer populations were evident in the later plantings. Discussions of some of the reasons for this are included, principally as regards the effect of the height of corn on egg deposition and the effect of the required length of the growing period of varieties on larval survival.

In 1927 investigations were begun by the Purdue University Agricultural Experiment Station at the Federal Corn Borer Station at Monroe, Michigan, with the object in view of determining the status of the delayed planting of corn in corn borer control. The studies of the first year consisted of a survey of 27 natural field plantings. Owing to the lack of any appreciable correlation, in many cases, between the planting date of corn and corn borer infestations and populations, it was evident that there were many and diverse factors which influenced the infestation in the fields studied. Consequently, in 1928, experimental plantings were made in an effort to determine some of the factors responsible for some of these differences, to gauge the relative importance of these various influences and to eliminate as far as possible those factors influencing infestation and population over which we had no control in the natural field plantings. A discussion of some of the progress made on these investigations is forthwith recorded.

The experiments in 1928 included three varieties of dent corn. An early variety, Northwestern Dent, a mid-season corn, Clement's White Cap, and a late variety, Johnson County White, were planted on May 7, May 24 and June 10. The same varieties were used in 1929 and plantings were made on May 10, May 20, June 1 and June 10. The 1930 studies included six varieties of dent corn and two sweet varieties. The two sweets were Golden Bantam and Stowell's Evergreen. Minnesota 23 was substituted for Northwestern Dent as an early dent variety and Wisconsin 8 and Silvermine were used as intermediate varieties as regards maturity between Minnesota 23 and Clement's White Cap and Clement's White Cap and Johnson County White. A late European variety, Dent de Cheval, was added. Thus, varieties covering a wide range of required growing periods were present in each of the four plantings which were made on May 7, May 20, June 2 and June 14.

EFFECT OF PLANTING DATE ON INFESTATIONS AND POPULATIONS. The result of delayed planting on the stalk infestations and borer populations of corn has been well marked over the three year period under discussion. When all of the varieties were classified on the basis of planting date, a decrease in the stalk infestation and subsequent borer load occurred in all of the delayed plantings (Table 1). The May 10 planting of 1929, however, contained less than its proportional borer load when compared to the second planting of the same season. This was due to the reduced vigor of the earlier planting resulting from cold, wet weather immediately following the seeding. The slower growth due to this unfavorable weather allowed the second planting made on May 20 to surpass the first one in height. Thus, the May 20 planting exceeded the May 10 by 4.90 inches in average height during the oviposition period. Another factor influencing egg deposition and survival, however, was partially responsible for the condition existing in this planting. The lower mean height of the first planting was to a large extent overcome by the increased egg deposition per plant unit as the result of a thinner stand of corn in the Johnson County variety of this planting. Although the factor of thickness of stand is not considered in this discussion it was found to be of considerable significance, particularly as regards its effect on the rate of egg deposition.

The June 14 planting of 1930, which, according to the table (Table 1) contained no borers at the time of dissection, was not actually free as an average of 4 eggs per 100 plants were taken in the 800 plants observed for eggs. However, no larvae were encountered in the plants when dissected.

TABLE 1. TABLE SHOWING COMPARATIVE DATA ON PLANTING DATE EXPERIMENT FOR 1928, 1929 AND 1930

Year	Number of varieties included	Planting date	Average height during oviposition period, in inches	Average silking date	Per cent of plants infested	Average number of eggs per 100 plants	Average number of live larvae per 100 plants
1928	3	May 7	31.00	July 22	86.66	558	97.00
1928	3	May 24	24.62	Aug. 1	25.33	106	18.00
1928	3	June 10	13.40	Aug. 11	1.33	18	.66
1929	3	May 10	45.88	July 20	100.00	2466	410.33
1929	3	May 20	50.64	July 27	100.00	2082	358.33
1929	3	June 1	28.51	Aug. 2	77.71	516	101.33
1929	3	June 10	19.39	Aug. 9	15.88	84	18.66
1930	8	May 7	27.41	July 31	44.50	812	68.10
1930	8	May 20	20.13	Aug. 5	19.75	337	27.61
1930	8	June 2	16.52	Aug. 12	10.75	174	13.00
1930	8	June 14	8.65	Aug. 18	0.00	4	0.00

EGG DEPOSITION. Plants were examined for eggs at three day intervals in each plot. Measurements of the height and stage in development of the corn were made at the time of each egg count and of the same hills. Height observations included measurements of the tallest plant in each hill taken at the bend of the topmost leaf. Stage in development records of the average dates of the beginning and maximum time of occurrence of tasseling and silking were taken. In 1930, records of leaf area were made on plants which were representative of the mean heights of the plots.

With the exception of the previously mentioned May 10 planting of 1929 which could not be readily compared with the other plantings due to the smaller number of plants per unit area, a significant positive correlation between the average heights of the plantings (Table 1) during the oviposition period, the average heights of the plantings at the peak of egg-laying and the number of eggs received, existed.

The comparative freedom of the delayed plantings from eggs was due to the fact that they did not receive eggs, in the presence of the taller plantings, until they had reached what might be termed an "attractive height." The average height at which all of the plantings began to receive eggs, exclusive of those plots which were tall enough and began to receive eggs at the beginning of oviposition, was 14.66 inches in 1928, 15.78 inches in 1929 and 13.53 inches in 1930. The minimum height at which a plot began to receive eggs was 8.41 inches. This was a plot of Clement's White Cap planted on May 20, 1930. The maximum height of any plant in the plot, however, was 11.00 inches. There was no significant correlation between the height at which various plantings began to receive eggs or at which the different varieties became attractive as oviposition plants. In 1929, the varieties in the May 10 and May 20 plantings were all above 18.00 inches in height when oviposition began and received eggs immediately. The June 1 planting received its first eggs when at a height of 16.53 inches and the June 10 planting at an average height of 14.86 inches. In 1930, the May 7 planting averaged 14.14 inches when it received its first eggs which was at the beginning of oviposition. The May 20 planting was first oviposited upon when it reached an average height of 11.59 inches, the June 2 planting at 15.12 inches and the June 14 planting at 10.45 inches. In all plantings, however, the heights of individual plants greatly exceeded these figures and it is probable that the height of the tallest plants in the plots was the factor deciding the beginning of egg deposition on the various plantings.

The direct effect of height on egg deposition in a single plot was emphasized in a plot of Clement's White Cap which was planted on May 7, 1930, and which contained hills of from 18 to 48 inches in height. The average for the plot was 34.40 inches. The tallest and most vigorous plants received more eggs than the shorter and less vigorous ones. Counts revealed that 61.30 per cent of the plants received eggs. The remaining 38.70 per cent were free of eggs during the entire season. Only 33.33 per cent of the plants which did not receive eggs were above the average height of the plot while 66.66 per cent of the plants which did not receive eggs were below the average of the plot in height. A total of 77.50 per cent of the eggs laid on the plants observed were deposited on those which were above the 34.40 inch level in height. The two tallest hills containing 6.00 per cent of the plants received 27.50 per cent of the eggs and were the first and last to receive eggs during the oviposition period.

An examination of the average date of silking of the plantings as indicative of their comparative maturity showed the same significant correlation when compared to egg deposition as did height. Likewise, any effect of earliness of corn on egg-laying which might have existed in the case of individual plants within a single plot could not be readily isolated as the more vigorous and rapidly growing hills or plants were the first to tassel and silk. The earliest and tallest plantings had also the greatest leaf area and the effect of this factor, if any, could not be established by comparisons of results classified according to the planting date of the corn.

The status of height as affecting egg deposition is quite clear when considering the plots involved in this study from the point of view of variety. An analysis of the 1930 data pertaining to the heights of the varieties studied showed a close correlation between the heights of these varieties and the number of eggs that they received in six out of eight cases. The exceptions were the sweet variety, Golden Bantam, which received more and the dent variety, Johnson County White, which received less than their expected quota of eggs when considered from the point of view of their comparative heights. In 1928 and 1929 the variety, Northwestern Dent, also received more eggs than the later varieties although at an equal or lesser height during the oviposition period. In 1929 it received an average of 2252 eggs per 100 plants with an average height of 47.80 inches as compared to 2210 eggs laid on Clement's White Cap with a height of 48.01 inches. The two varieties, Golden Bantam and Northwestern Dent, were also inferior in height to some other varieties throughout that part of the period when

75 per cent of the eggs were laid and yet received more eggs. On the other hand the earliest variety to silk and tassel, Minnesota 23, did not show this relationship. It seems probable that some factor or combination of factors of which height and stage in development are not altogether indicative assist in rendering these varieties more attractive than the others studied.

LARVAL SURVIVAL. Stalk dissections for determinations of the larval survival were made in late August before the normal Fall migration of borers had noticeably effected stalk populations.

An analysis of the borer populations of the plots over the three-year period shows that the rate of survival of larvae differed greatly in this locality during the various years. Thus, the percentage of survival from egg to full-grown borer in 1928 was 19.13 per cent, in 1929, 22.96 per cent and in 1930, 8.37 per cent. A comparison of the same varieties over the three year period would probably give a closer estimate of the comparative favorableness of the three seasons as regards larval establishment and survival. The rate of survival on Johnson County White in 1928 was 15.40 per cent, in 1929, 18.58 per cent and in 1930 it was 5.40 per cent. The comparative survivals in the dent variety, Clement's White Cap, for the three seasons were 17.00 per cent, 21.11 per cent and 7.35 per cent respectively. These figures represent the average for all of the plantings made during the three seasons.

TABLE 2. TABLE SHOWING COMPARATIVE DATA RELATIVE TO LARVAL SURVIVAL IN VARIETIES STUDIED IN 1930, ARRANGED ACCORDING TO THEIR REQUIRED LENGTH OF GROWING PERIOD

Variety	Average height during oviposition period, in inches	Average silking date	Average number of eggs per 100 plants	Average number of live larvae per 100 plants	Per cent survival
Minnesota 23	27.98	July 10	388	63	16.23
Golden Bantam	23.27	July 19	458	65	14.17
Wisconsin 8	31.68	July 22	511	43	8.41
Clement's White Cap	29.28	Aug. 1	476	35	7.35
Silvermine	27.86	Aug. 6	388	21	5.41
Stowell's Evergreen	21.47	Aug. 7	317	18	5.76
Johnson County White	28.16	Aug. 17	370	20	5.40
Dent de Cheval	31.70	Aug. 20	581	25	4.30

When the various plots were classified according to planting date there was only a very slight difference in the rate of survival. The 1930 season showed the greatest variation in this respect. The May 7 planting had a survival rate of 10.11 per cent, the May 20 planting 7.61 per cent and the June 1 planting 7.07 per cent. No survival figure was established for the June 14 planting because of the small number of eggs

and larvae which occurred in these plots. This difference of 2.50 per cent could hardly be considered significant. When the plots were classified according to variety, the two varieties, Golden Bantam and Minnesota 23, had a slightly higher survival rate in the first planting made on May 7 than in the other plantings. It was because of this influence that the survival figure for the May 7 planting of 1930, when considered as a whole, was slightly higher than for the later plantings. The fact that these varieties silked and tasselled during the active hatching period of the eggs may have influenced the survival rate.

In any given season the survival rate varied according to the required period of maturity of the varieties which were used, the earlier varieties indicating a more favorable condition for establishment than the later ones. This was true of both sweet and dent corn (Table 2). The European variety, Dent de Cheval, had the lowest rate of establishment of any of the corns studied. This variety which did not silk until August 20 was far from maturity at the time of harvesting. Likewise, the variety Minnesota 23 which was the earliest variety studied, had a correspondingly high rate of survival.

Discussion. Three years of investigation of the effect of planting date on corn borer populations has shown that in the presence of early plantings, the populations of later plantings were much reduced and extremely late plantings were almost entirely free. Other conditions being equal, the delayed planting of corn may be relied upon to reduce the borer load. In natural field plantings where such factors as soil, variety, fertility, planting rate, etc., were variable the planting date was not always an index to the borer infestation or population.

The comparatively light infestations in the late plantings were thought to be due almost entirely to height. The fact that the late plantings did not receive eggs until they had reached what might be termed an attractive height seemed important. As was previously pointed out by Patch (1), and Neiswander and Huber (2), height appeared to be an index to the most important factors governing egg-laying and the required growing period of the varieties an index to the factor or factors chiefly responsible for variations in the rate of larval survival.

The effect of planting date, infestation, and variety on the yield has not been stressed in these studies because the results would not apply directly to Indiana conditions. This problem has been under investigation in Indiana since 1927 where a large number of varieties and planting dates are being studied by the Department of Agronomy. The infestation, however, has been so light that the entomological

phases of these investigations have not yielded information of significance. With the expected increase in the intensity of the infestation more effort will be given to planting date studies under Indiana conditions.

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PRESIDENT FRANKLIN SHERMAN: We will now listen to a paper by E. G. Kelsheimer and J. B. Polivka.

CORRELATION OF CORN BORER SURVIVAL WITH MATURITY OF CORN

By E. G. KELSHEIMER and J. B. POLIVKA, *Ohio Agricultural Experiment Station, Wooster, Ohio*

ABSTRACT

Data presented show a significant correlation between borer (*Pyrausta nubilalis* Hubn.) survival and host development.

Investigators who have given the problem closest attention are agreed that height of corn at the period of moth flight is a dominant factor influencing the oviposition responses of the insects to corn. This relationship was first pointed out in work done in 1926 (1). These conclusions have been confirmed by other data obtained by the writers as well as by Patch (2). It would appear, however, that the relationship between the rate of survival and silking date is not quite so convincing.

In all experiments conducted by the Ohio Station a significant correlation has been found between the rate of larval survival and the development of corn. That is, corn planted late has a lower rate of survival than corn planted early. However, in 1929 Patch stated that "borers hatching in corn planted June 1 have as good a chance to survive and reach maturity as those hatching in corn planted earlier." Additional experiments were conducted in 1930 to obtain further data on the relationship between survival and date of planting.

A single variety of corn, Smoky Dent, was planted on two dates May 15 and June 8. The experimental units consisted of plots of twenty stalks each, replicated five times. Each stalk of both planting dates received 50 eggs on the same date.

The number of larvae attaining the full grown stage in the early planted corn was approximately four times as great as in the late planted corn. Table 1 shows the number of stalks with the population per stalk for the two dates of planting.

TABLE 1. SHOWING POPULATION PER STALK FOR CORN PLANTED MAY 15 AND JUNE 8, 1930

No. of borers per stalk	May 15 No. of stalks	June 8 No. of stalks
0	1	46
1	5	28
2	20	14
3	15	7
4	17	4
5	15	–
6	8	–
7	11	1
8	4	–
9	3	–
10	1	–
Av. pop.	4.21	1.0
Difference		3.21

The data presented show a difference of 3.21 borers per stalk for the two dates of planting. This does not take into consideration the natural infestation. According to the formula $t = \frac{X-X^1}{S}\sqrt{\frac{(N_1+1)(N_2+1)}{N^1+N^2+2}}$ by Fisher, the odds are 3,333,332 to 1 that this difference is not due to chance.

Allowing for a natural infestation correction of .12 borers on corn planted May 15 and .01 borers for corn planted June 8, the early corn had an average of 4.09 borers per stalk while the late planted corn had an average of .99 borers per stalk showing a difference of 3.1. The odds remain the same as for the above.

The larval survival and silking date for the early and late planted corn are given in Table 2. In general the percent of larval survival is in direct correlation with earliness of planting and likewise the earliness of silking.

TABLE 2. SHOWING LARVAL SURVIVAL AND SILKING DATE ON CORN PLANTED MAY 15 AND JUNE 8, 1930

Plot No.	Planted May 15 Average silking date	Planted May 15 Percent larval survival	Planted June 8 Average silking date	Planted June 8 Per cent larval survival
1	7–29	9.4	8–13	2.5
2	7–30	8.5	8–10	.9
3	7–30	9.1	8–11	3.4
4	8–1	7.7	8–11	1.7
5	8–1	8.0	8–12	1.5

The correlation coefficient between silking date and percent of survival is — .98. The odds calculated from the formula $t = \frac{r}{\sqrt{1-r^2}} \times \sqrt{N^1-1}$ as given by Fisher are 9,999 to 1 that this is a significant correlation.

The relationship between date of planting and survival for one variety of corn has been shown. The following data furnished further evidence of the relationship existing between maturity and survival. These data were obtained from an early, medium and late maturing variety of corn planted May 8 and receiving only natural egg deposition.

TABLE 3. SHOWING LARVAL SURVIVAL AND SILKING DATE FOR THREE VARIETIES OF CORN PLANTED MAY 8 AND RECEIVING NATURAL EGG DEPOSITION

Plot	Golden Bantam		Minnesota		Burr-Leaming	
	Average silking date	Per cent larval survival	Average silking date	Per cent larval survival	Average silking date	Per cent larval survival
1	7–29	13.0	8–1	3.39	8–9	3.99
2	7–29	9.0	8–1	2.48	8–7	2.72
3	7–29	9.0	8–1	3.1	8–7	1.11
4	7–28	7.4	8–1	2.44	8–6	2.04

As indicated in Table 3, Golden Bantam, an early maturing sweet corn, has the highest survival of the three varieties with Minnesota and Burr-Leaming following in the order of their maturity. That these differences in survival are significant is indicated by a correlation coefficient of — .71 and odds of 262 to 1.

These data show that there is a significant difference in the per cent of corn borer survival in early and late planted corn. Further, these data show that the difference in development of a single variety planted on two different dates may be equivalent to the difference obtained in different varieties planted on the same date.

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PRESIDENT FRANKLIN SHERMAN: We will next listen to a paper by C. R. Neiswander and J. R. Savage.

MIGRATION AND DISSEMINATION OF EUROPEAN CORN BORER LARVAE (*PYRAUSTA NUBILALIS* HUBN.)

By C. R. NEISWANDER and J. R. SAVAGE, *Ohio Agricultural Experiment Station*

ABSTRACT

Data presented in this paper show the period, distance and amount of larval dispersion that occurred in a series of experiments extending over a period of three years.

The extent to which the corn borer larvae that develop from a given egg mass may become distributed is of considerable importance in evaluating the differences in population that occur in different varieties or plots of corn. The attractiveness, repulsiveness or degree of immunity of a given plot may be more, or less significant than the population of the plot itself indicates because of the migration or dissemination of larvae to or from the plot. Accordingly, during the past two or three years a study has been made of the time, distance and manner of larval dispersion together with the factors that influence it.

In 1929 and 1930 a series of experiments was conducted in which the central hills of a number of otherwise uninfested plots were infested artificially in order to determine the distribution of the ensuing larval population. Known numbers of eggs were placed on these centrally located hills and the developing larvae were permitted to distribute themselves without hindrance. All tests were conducted in triplicate.

The distribution of larvae recovered for each of the two years is given in Table 1. The central hill refers to the hill on which the egg masses were placed and the border rows refer to the successive tiers of hills surrounding the source of infestation.

TABLE 1. SHOWING AMOUNT AND DISTANCE OF LARVAL DISPERSION—1929 AND 1930

		Larvae recovered in											
	Total larvae	Central hill		1st border		2nd border		3rd border		4th border		5th border	
Year	recovered	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
1929	279	142	50.9	79	28.3	30	10.8	7	2.5	20	7.2	1	.4
1930	326	230	70.6	87	26.7	8	2.5	1	.3	0	0	0	0

A study of Table 1 shows a considerable difference in the number of larvae recovered on their original hills for the two years, there being a variation of approximately 20 per cent. The distance of larval dispersion is also quite varied in the two years. Other records taken at the Ohio Station although somewhat less extensive nevertheless indicate that the 1929 record is the more nearly normal and that about 50 per cent of the larvae recovered from a given egg deposition had dispersed to hills other than the one on which they originated. The explanation for the low dispersion record for 1930 probably lies in the abnormal

weather conditions prevailing during the dissemination season. The effective weather factors were no doubt the extremely low humidity and the non-occurrence of severe winds and storms. Figures 22 and 23 illustrate the difference in the summation of the dissemination pattern for the two years.

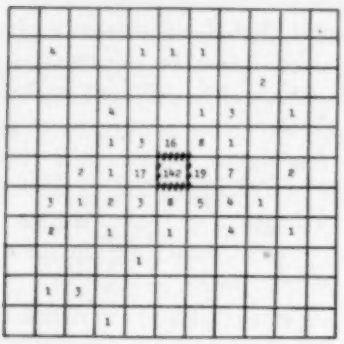

FIG. 22.—Summation of larval distribution in migration plots, Oak Harbor, 1929.

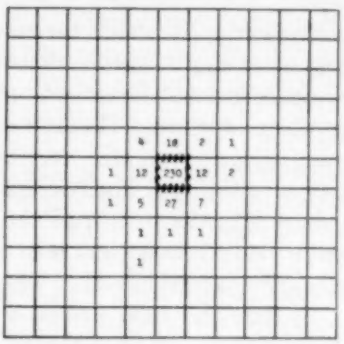

FIG. 23.—Summation of larval distribution in migration plots, Wooster, 1930.

The distribution of the foregoing infestation has come about through two modes of dispersion, (1) aerial drift of newly hatched larvae, and (2) migration of full grown larvae on the ground surface.

In one 1929 dissemination experiment a trap was placed around the central hill of each replication of the experiment in order to prevent the *migrating* larvae from infesting the surrounding hills. In this way the infestation occurring outside of the traps must have resulted from larvae that had been carried over the traps in air currents. In this experiment there were five levels of infestation established with each level duplicated. However, because of the fact that the survival was so low some of the plots had too small numbers of larvae established to make the migration for each level significant. Nevertheless when the series is considered as a whole the results are of interest.

TABLE 2. SHOWING SEPARATION OF TOTAL DISPERSED BORERS INTO THOSE MIGRATED ON SOIL SURFACE AND THOSE CARRIED OVER THE TRAPS IN AIR CURRENTS

Replication No.	Total borers recovered on plants other than original host	Borers migrated on soil surface (Taken in traps)		Borers carried by air currents (Taken in surrounding hills)	
		No.	Pct.	No.	Pct.
1	40	13	32.5	27	67.5
2	44	17	38.6	25	61.4
Totals	84	30	35.7	54	64.3

No migrants were found in the traps until the larvae were full grown. Evidence of infestation in the surrounding hills was observed, however, at practically the same time as was that of the central hill. It is thus indicated that larval feeding must have started almost simultaneously and that drift dissemination occurred soon after hatching as has been observed repeatedly. It may be noted from Table 2 that nearly twice as many borers were recovered in the surrounding hills as were taken in the traps. This would indicate that, for 1929, the effective drift dissemination was greater than the effective migration of full grown larvae. This relationship undoubtedly fluctuates considerably from year to year as a result of the fluctuation in climatic conditions, particularly winds. Nevertheless the data indicate that there are two rather important modes of larval dispersion.

PERIOD OF LARVAL MIGRATION. During the three seasons 1928 to 1930 a study has been made of the time of the year at which larvae migrate. Traps were placed around infested hills and these traps were observed every second or third day throughout the migration season. The trap recoveries by two-week periods are given for two years in Table 3. The second year, 1929, is omitted from the record because of the fewness of individuals migrating in that year's experiment.

TABLE 3. TRAP RECOVERIES FOR TWO YEARS AT OAK HARBOR

Year	Aug. 1–15	Aug. 16–31	Sept. 1–15	Sept. 16–30	Oct. 1–15	Oct. 16–31	Nov. 1–15	Total
1928	0	71	38	9	26	–	–	144
1930	0	16	164	36	4	6	–	226

It may be seen from the record that the highest period of migration in 1928 was the last half of August while in 1930 more than 70 per cent of the migration occurred during the first two weeks of September. For both years the period of migration extended from the middle of August to the latter part of October.

As a subordinate part of this same experiment an early and a late variety of corn were used at the migration source in order to determine whether or not the amount of migration would be greatly stimulated by the ripening of the corn. The two varieties grown were the short season Smoky Dent and the long season Burr-Leaming, both being planted on the same date. The average silking date for the Smoky Dent was August 7 while that for Burr-Leaming was August 18, there thus being an eleven day difference in time from planting to silking. The increased amount of migration in Smoky Dent, Fig. 24, was undoubtedly due to the fact that the early variety had the higher establishment and for this reason had a greater number of borers available for migrating. The higher population also caused greater compe-

tition among larvae for food and space. The period of migration, however, was almost identical for the two varieties in spite of the difference in maturity.

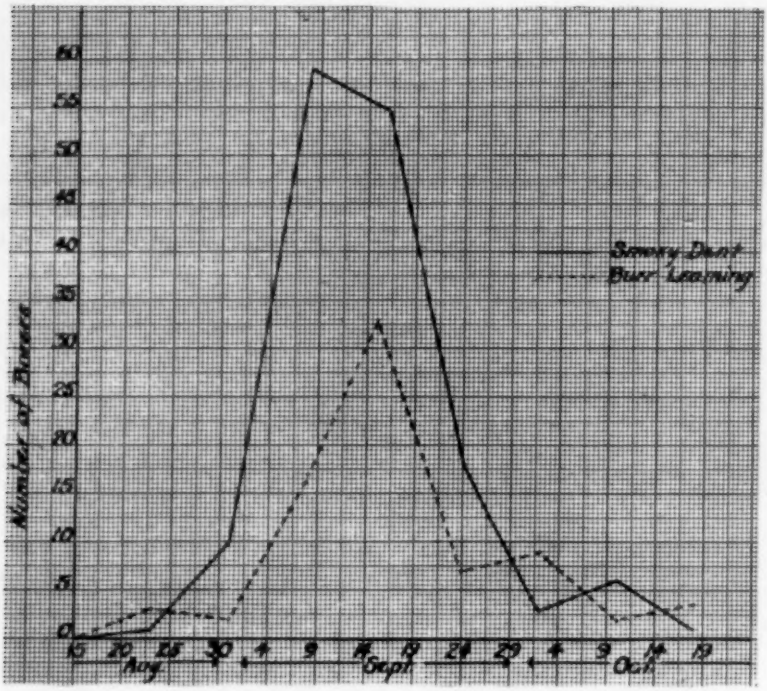

FIG. 24.—Graph Showing Period and Amount of Migration from Smoky Dent and Burr-Leaming Varieties, Oak Harbor, 1930.

DISPERSION UNDER DIFFERENT RATES OF INFESTATION. In 1930 a further study was made of the variation in the amount of dispersion resulting from different populations at the source. Infestations were introduced at the rate of 200, 500 and 1,000 eggs per hill respectively on three replications of each level.

TABLE 4. SHOWING EFFECT INCREASE IN POPULATION PER STALK AT SOURCE HAS ON THE AMOUNT OF DISPERSION

Eggs Deposited per hill	Borers recovered total	Av. pop. per st'k at source	Larvae migrated and disseminated to: Larvae in central hill		1st border		2nd border		3rd border		4th border	
			No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
200	52	4.7	42	80.8	10	19.2	0	0	0	0	0	0
500	94	8.1	73	77.7	20	21.3	1	1.1	0	0	0	0
1000	180	12.8	115	63.9	57	31.7	7	3.9	1	0.6	0	0

As shown in Table 4 the amount of dispersion increased as the population at the source increased, competition for food and space no doubt being the regulating factor. The distance to which larvae spread also increased with the population at the source. This was probably due to the increased chance of going long distances that comes with large numbers.

LARVAE LOST IN MIGRATION. At the beginning of the migration season in 1930, a total of 150 to 200 full grown larvae were released at intervals in the middle of each of six uninfested plots eight hills square, the objective being to determine the number of larvae able to establish themselves on other plants after once migrating from their original hosts. Out of 1,300 larvae released within the plots just 66 or 5.1 per cent were recovered when all stalks in the plots were dissected during the latter part of October. A single previous experiment conducted in 1926 had given a 46 per cent recovery. While the recovery in 1930 may have been lower than normal as a result of unfavorable weather conditions, nevertheless the results indicate a high mortality of migrating larvae. This high death rate in the act of becoming distributed, together with the amount of movement that has been shown to occur, serves to explain the fall and spring decreases in field populations that have been noted repeatedly by investigators.

PRESIDENT FRANKLIN SHERMAN: The next paper is by L. L. Huber and C. R. Neiswander.

SOME CAUSES CONTRIBUTING TO EUROPEAN CORN BORER ABUNDANCE

By L. L. HUBER and C. R. NEISWANDER, *Ohio Agricultural Experiment Station, Wooster, Ohio*

(Withdrawn for publication in Ecology)

MR. A. L. STRAND: I do not understand how you base the figures on resistance.

MR. L. L. HUBER: The ratio of the biotic potential and the actual population we assume has a biotic potential of 200. It is not accurate but it is nearly so. The actual populations are taken from records of the Federal Department of Agriculture in combination with our own.

PRESIDENT FRANKLIN SHERMAN: We will now hear a paper by J. B. Polivka.

THE EFFECTS OF PHYSIOLOGICAL CHANGE IN THE CORN PLANT ON CORN BORER SURVIVAL

By J. B. POLIVKA, *Ohio Agricultural Experiment Station, Wooster, Ohio*

ABSTRACT

This paper points out the necessity of considering corn development in determining the true value of an insecticide used in corn borer (*Pyrausta nubilalis* Hubn.) control.

The determination of the efficiency or inefficiency of an insecticide against the corn borer is usually based on the number of insects found in the treated plot as compared with those found in the check. This difference in population, if any occurs, is accredited to the lethal effect of the insecticide on the insect. Experiments with insecticides against the corn borer indicate, however, that physiological change in the corn plant should be considered as a factor in the reduction in population.

Experiments that have been conducted with varieties of corn have brought out the fact that certain physiological differences in the plants produce significant differences in the response of the corn borer. As for example, it has been shown previously (1) that for each day's delay in silking there is a coincident reduction of about 4% in borer population. The partial explanation of the fluctuation in the abundance of the borers, therefore, is found in the responses of the plant itself. For the foregoing reasons it would seem essential in insecticide investigations to measure the development and yield of the corn plant as well as to determine the borer population.

Experiments in 1928 with sodium fluosilicate showed that the heavier applications of the material resulted not only in a reduction in borer population but also in a decrease in yield which was accompanied by a delay in date of silking.

In 1929 similar tests were made with materials such as lime, gypsum and infusorial earth. A very close similarity to the 1928 effect of sodium fluosilicate was shown by the infusorial earth, the use of which was accompanied by approximately a 50% reduction both in borer population and yield. While no development records were taken on these plots the data obtained seemed to indicate that a disturbance of the physiology of the plant occurred and that a part of the reduction in borer population was due to this disturbance.

In 1930 by varying the causal factor, experiments were conducted to obtain more specific data on the effect physiological changes in the corn plant have on survival and yield. These disturbances were inaugurated by (1) breaking the leaves, (2) pruning the roots, (3) capping the ears, and (4) spraying with 8 per cent verdol oil. The experimental units consisted of plots 4 by 10 rows, replicated 3 times.

Due to the abnormal weather conditions of 1930, egg deposition was so light on these experimental plots that it was impossible to obtain dependable records relative to the per cent survival associated with the different treatments. However, the yield of these plots was greatly reduced due to the treatment applied. The check plots averaged 62.9 bushels per acre, while the plots which were root pruned averaged 48.5 bushels, those with the leaves broken 43.0 bushels and those sprayed with 8 per cent verdol 34.8 bushels per acre. These differences in yield have been found to be significant.

It has been shown by other workers that climatic factors affect the yield of corn; that yield is a measure of development of corn and that development influences the per cent survival of the corn borer. It would seem logical to conclude therefore that the survival of the corn borer would be affected if the development of the corn is retarded by mechanical and insecticidal treatments. The information now available on corn borer behavior points to the probability that in evaluating an insecticide it is essential to give due consideration not only to its direct but also to its indirect influence.

PRESIDENT FRANKLIN SHERMAN: The last paper in this series is by F. L. Simanton, F. F. Dicke and G. T. Bottger.

THE LETHAL POWER OF CERTAIN INSECTICIDES TESTED IN MICHIGAN AGAINST THE EUROPEAN CORN BORER

By F. L. SIMANTON, F. F. DICKE, and G. T. BOTTGER, *U. S. Bureau of Entomology*

ABSTRACT

This is a progress report of tests to determine the effectiveness against the European corn borer (*Pyrausta nubilalis* Hubn.) of insecticides commonly used in insect control, and also of certain promising but less known insecticides.

The objective of this work was the discovery of an effective and economical insecticide for the control of the European corn borer. Field plots ranging in size from 1 square rod to 160 square rods were used. In so far as possible the plots have been 20 square rods in area.

APPARATUS. Testing has been done in both the wet and dry ways with particular attention given to dust applications because of the ease and rapidity with which poisons can be applied in this manner. All dustings were made with a rotary type of hand duster except five dustings made in 1930 with a power duster.

Liquid applications, except in a few instances at the beginning of the project, have been made with a power sprayer having a capacity of 3

gallons per minute and operated at about 180 pounds pressure. All applications have been made by one of a crew of three experienced sprayers. The spray solution was applied to the plants until the liquid was nearly ready to drip. The number of gallons used per acre has depended on the variety of corn, its age, and the air movement. On an average 150 gallons per acre were required.

Very little was known at the time this project was undertaken as to how the corn plant would react to insecticide materials and nothing definite concerning the susceptibility of the corn borer to certain poisons.

Spreaders, Adhesives, Stabilizers, and Diluents. Various materials in these groups, including lime, talc, soap, iron oxide, bentonite, and diatomaceous earth, were used in combination with the various insecticides under test. In general, they functioned according to expectations, but their contribution to the effectiveness of the insecticides has been small. In this treatise they have been disregarded, and the kill in each instance is credited entirely to the poison with which each material was used. In the case of dusts, there was very little choice among the diluents and fillers. When properly pulverized and sufficiently dry, all of those tried gave satisfaction.

The Control. Homogeneous distribution of a corn-borer population has not been encountered at any time. It seems more and more evident that corn borer populations are naturally "spotty," a condition that permits large and erratic variations of adjacent plot populations from each other and from their mean.

At first it was assumed that the larval population in uniform stands of corn would tend to be uniformly distributed and that the check areas could be smaller than the areas of all treated plots. It was later evident that this scheme did not always show equal populations in treated plots and checks. An effort to remedy this by increasing the number of check plots has decreased the error but has failed to remove it. Testing by the Latin Square method of Fisher was tried during the past season with indications that the differences between check populations and the initial treated populations has been materially reduced.

Experience shows that the ratio between the number of infested plants—meaning plants that have been attacked—and the larval populations in these same plants is quite variable, changing from place to place and from year to year, and differing with the kinds of corn, variations of rainfall, and possibly with other environmental factors. Since the object is to kill borers, the plant-infestation comparison has been discarded in favor of a population comparison which states actual

control. Thus: the number of larvae to be killed equals the check population; the number of larvae surviving is the residual population in the treated plot; the per cent of control is the difference between the check population and the residual population in each treated plot expressed as a percentage of the check population.

SIZE OF SAMPLES. To compensate in part for the erratic distribution of corn borer populations, the samples used have been as large as available help would permit. From 50 to 150 infested plants were dissected in each plot, and the number of plants carefully examined to get the infestation has ranged from 100 to 1,000, according to the size of plot, the population level, and the available time. Whenever the plot distributions would permit, the separate check data have been grouped so as to use an average of approximately 400 plants.

POPULATION LEVELS. The average populations have varied. The work done in 1927 was with an average population of 67 larvae per 100 plants. The highest was 975 larvae per 100 plants in 1929. The lowest was 21 larvae per 100 in 1930.

WEATHER. In this four-year period, one year has been wet, one moderately wet, one moderately dry, and the last one very dry and hot. The populations were highest during the wet years.

KINDS OF CORN. The first year's work was done with dent corn, but in each of the following years both dent and sweet corn were used. The populations have been larger in the sweet corn, and more tests have been tried on it, partly because of these higher infestations and partly because sweet-corn growers were in need of immediate relief. The control problem is essentially the same for both varieties, and for the purpose of this article, which is to show the relative effectiveness of the poisons employed, the data from both kinds of corn are grouped without distinction.

NUMBER OF APPLICATIONS. In the case of materials that might have both ovicidal and larvicidal potencies, the first application was made at the date of maximum oviposition, a second application at the beginning of migration of first-instar larvae, and a third at its maximum.

The larvicides were applied just before and just after the maximum hatch, and again four days later to cover new growth.

Various modifications of this basic schedule were made, the data from which are included in tables that follow.

The sprays have been applied according to the above schedules, but the dusts have been mostly applied four times in the interval covered by the three sprayings.

FORMULAE. The first applications had 4 pounds of killing agent to 100 gallons of water. Later experiences showed that the corn plant was seldom injured when treated at this concentration, and it has been generally used.

Similarly the standard for dust comparisons has been 20 per cent of killing agent with 80 per cent of carrier. Other formulae in both liquid and dust media have been tried and their controls are given in the tabulations.

DOSAGES. Liquid applications have required from 150 to 200 gallons of spray per acre. The quantity has varied with the size of the treated plants.

Dust applications, when made by hand dusters, have required from 30 to 50 pounds of material per application per acre.

The dust applications with a power duster have been made with 10 pounds per acre per application. The difference in dosage should be considered in drawing conclusions.

MAJOR INSECTICIDES

LEAD ARSENATE (Table 1). Lead arsenate has left the corn plants uninjured, but has failed to make high kills at reasonable cost. When used at 4 pounds per 100 gallons of water, one application has killed about 20 per cent of the larvae present, two applications 40 per cent, and three applications 50 per cent.

When used as a dust diluted to 20 per cent with a fine, dry filler, and applied row by row with a hand duster, three applications of lead arsenate have made a kill of about 25 per cent, and four applications 45 per cent. When diluted one-half and applied five times as above, it makes a kill of about 75 per cent. When applied pure, the kill is high but expensive.

TABLE 1. AVERAGE KILLS OBTAINED BY USING LEAD ARSENATE, AS SPECIFIED, AGAINST VARIOUS CORN-BORER POPULATIONS, IN BOTH SWEET AND DENT CORN

Killing agent	Number of applications	Number of trials	Average kill per cent
Liquid with power sprayer			
4 lbs. in 100 gal. water	one	six	23
	two	eleven	41
	three	ten	47
Dust with hand duster			
20 lbs. with 80 lbs. filler	three	nine	24
	four	six	46
50 lbs. with 50 lbs. filler	two	one	31
	five	two	74
Pure	five	one	90

CALCIUM ARSENATE (Table 2). Calcium arsenate has at times caused slight injury to sprayed corn, especially when not used with lime. Table 2 indicates that it is no more effective than lead arsenate. When used as a dust, it has not injured the treated corn. The power dustings, as previously stated, used 10 pounds per acre per application, whereas the hand dusters used from 30 to 50 pounds.

TABLE 2. AVERAGE KILLS OBTAINED WITH CALCIUM ARSENATE IN VARIOUS CORN-BORER POPULATIONS IN BOTH SWEET AND DENT CORN

Killing agent	Number of applications	Number of trials	Average kill per cent
Liquid with power sprayer			
4 lbs. in 100 gal. water	one	five	30
	two	seven	45
	three	six	36
Dust with hand duster			
20 lbs. with 80 lbs. filler	three	five	32
	four	two	43
Dust with power duster			
Same	eight	one	25

BARIUM FLUOSILICATE. (Table 3). Barium fluosilicate was tested in 1928, but the material then used caused serious injury. It was accordingly dropped from the list of materials for further trials. Material from other sources having been secured, the tests were resumed in 1930. At 4 pounds to 100 gallons of water, when applied twice, it has caused moderate bleaching on as many as 50 per cent of the leaves. The weight of corn plants has not been noticeably reduced. At 2 pounds per 100 gallons, applied once, 20 to 40 per cent of the leaves were more or less bleached. The kill has been quite satisfactory as Table 3 shows. The characteristic fluorine bleach has appeared in the dusted plots but it was not accompanied by reduced yields.

TABLE 3. AVERAGE KILLS SECURED WITH BARIUM FLUOSILICATE IN VARIOUS CORN-BORER POPULATIONS IN SWEET AND DENT CORN

Killing agent	Number of applications	Number of trials	Average kill per cent
Liquid with power sprayer			
2 lbs. in 100 gal. water	one	five	86
4 lbs. per 100 gal	one	one	86
	two	two	92
Dusts with hand duster			
20 lbs. with 80 lbs. filler	two	two	41
	three	one	50

CALCIUM FLUOSILICATE[1] (Table 4). Calcium fluosilicate has been under test every year and has consistently given satisfactory kills with a minimum of bleaching. Fluorine bleaching has mostly been present in sprayed plots but in no instance has it caused a noticeable decrease in yield. Where 12 pounds in 100 gallons of water was applied, once, and replicated five times, there was no significant decrease in weight. The treated plant sample weighed 73.5 pounds and the check sample, also replicated five times, weighed 74 pounds.

TABLE 4. AVERAGE KILLS SECURED WITH CALCIUM FLUOSILICATE IN VARIOUS CORN-BORER POPULATIONS WHEN BOTH SWEET AND DENT CORN WERE TREATED

Killing agent	Number of applications	Number of trials	Average kill Per cent
Liquid with power sprayer			
4 lbs. in 100 gal. water	one	two	32
	two	six	68
	three	three	68
5 lbs. in 100 gal.	one	two	56
	two	one	78
6 lbs. in 100 gal.	two	one	60
	three	four	81
12 lbs. in 100 gal.	one	five	87
Dusts with hand duster			
20 lbs. with 80 lbs. filler	three	four	56
	four	one	57
25 lbs. with 75 lbs. filler	three	two	66
30 lbs. with 70 lbs. filler	five	one	60
50 lbs. with 50 lbs. filler	six	three	70
Dusts with power duster			
25 lbs. with 75 lbs. filler	eight	two	30

SODIUM FLUOSILICATE (Table 5). Sodium fluosilicate has consistently injured corn in all tests. It has also consistently killed a large

	Per cent
CaO	20.72
SiO_2	5.96
Fluorine	12.48
Iron and Aluminum Phosphates	31.10
P_2O_5	27.34
SO_3	.40
Moisture	11.25
Loss on Ignition	34.00

[1]The calcium fluosilicate used was not pure. The manufacturer furnished the following analysis:

part of the borer population. At 4 pounds per 100 gallons of water, when applied once at approximately 175 gallons per acre, it has on occasion reduced yields of sweet corn by one-half. At one-half this strength with one application, bleaching has appeared on from 25 to 50 per cent of the leaves, but without reducing the weight of the treated corn plants. When used as a 20 per cent dust with two applications at approximately 35 pounds per acre per application, it has produced mottling and has reduced yields. Efforts to reduce its toxic effect on corn plants by the use of stabilizers, and by using different fillers, have failed.

TABLE 5. AVERAGE KILLS SECURED WITH SODIUM FLUOSILICATE IN VARIOUS CORN-BORER POPULATIONS WHEN BOTH SWEET AND DENT CORN WERE TREATED

Killing agent	Number of applications	Number of trials	Average kill Per cent
Liquid with power sprayer			
2 lbs. in 100 gal. water	one	six	66
	two	two	76
4 lbs. and 4 lbs. hyd. lime in 100 gal.	one	one	84
Dust with hand duster			
20 lbs. with 80 lbs. filler	three	one	64
	one	two	58
	two	one	83
30 lbs. with 70 lbs. filler	five	one	82
50 lbs. with 50 lbs. filler	five	one	99
	six	one	100

NICOTINE (Table 6). Nicotine, in the form of tobacco dust and as nicotine sulphate, had eight tests.

It has not caused injury to corn at any time, and it has failed at all times to make good kills. The dusts were directed against hatching eggs and larvae.

TABLE 6. AVERAGE KILLS SECURED WITH NICOTINE WHEN USED AS SPECIFIED AGAINST VARIOUS POPULATIONS OF CORN BORERS IN SWEET AND DENT CORN

Killing agent	Number of applications	Number of trials	Average kill Per cent
Liquid with power sprayer			
.5 lb. nic. sulphate[1] in 100 gal. water	three	one	51
	one	one	27
	two	two	43
Dust with hand duster			
Tobacco dust (1 per cent nicotine)	two	two	15
	four	two	19
	three	one	0
Tobacco dust (2 per cent nicotine)	three	one	7
	eight	one	0
3 per cent nic. sulphate[1] in hyd. lime	four	two	0

[1]Derived from a 40 per cent commercial solution but calculated as pure nicotine sulphate.

PYRETHRUM AND ITS EXTRACTS (Table 7). Pyrethrum as used has not injured treated corn. At present it seems that equal control can be obtained at less expense by other means. Kills above 70 per cent have been obtained both by spraying and dusting.

TABLE 7. AVERAGE KILLS OBTAINED WITH PYRETHRUM, AND ITS EXTRACTS WHEN USED AGAINST CORN BORERS IN SWEET CORN

Killing agent	Number of applications	Number of trials	Average kill Per cent
Liquid with power sprayer			
2 pints of pyrethrum extract[1] in 100 gal. of water	three	one	77
Dust with hand duster			
Buhach powder undiluted	three	three	39
Buhach, 20 lbs, with talc, 80 lbs.	three	one	71
	two	one	55

[1]Extract is composed of:
Water .37 per cent
Inert resin .30 per cent
Active ingredients .33 per cent

TALC (Table 8). The control obtained with talc has been erratic. When tested in a small way in 1929, one application showed a control of 61 per cent. It was stressed in 1930, both as a killing agent and as a filler. Some of the trials show a good kill and others do not. As a carrier and filler for preparing dusts, it has many desirable properties, but the kills are not increased when it is used instead of hydrated lime. More data are needed before it can be properly rated.

TABLE 8. AVERAGE KILLS WITH TALC WHEN USED AS A LARVICIDE AGAINST THE EUROPEAN CORN BORER

Killing agent	Number of applications	Number of trials	Average kill Per cent
Liquid with power sprayer			
10 lbs. in 100 gal water	one	one	61
15 lbs. in 100 gal. water	two	one	50
	three	one	56
Same with ½ per cent sulphonated oil[1]	three	one	20
Dust with hand duster			
Talc, 98 lbs. with 2 lbs. lead arsenate	three	one	76
Dust with power duster (10 lbs. per acre per application)			
Talc, 98 lbs. with 2 lbs. lead arsenate	eight	one	0

[1]Composition:
Oxidized petroleum hydrocarbons (32°–40° Be.) sulphonated .90 per cent
Inert ingredients .10 per cent

KILLS SECURED WITH CERTAIN FLUORINE COMPOUNDS IN 1930 (Table 9). Promising results were secured in 1930 by spraying dent corn, having an average population of 30 larvae per 100 plants, with a single application of certain fluorine compounds at the rate of 2 pounds per 100 gallons of water. Each chemical was applied once to five plots of 1 square rod each. These plots were arranged in Latin Squares. Plant injury due to treatment has consisted almost entirely of mottling. The weights, determined from a sample of 20 plants from each plot, have been equal to, or greater than, the weight of like samples from the check plots, except in three instances. The greatest decrease in these was less than one-half of 1 per cent of the weight of its check. No indications of spray injury were noted in this plot. The season of 1930 was abnormal, being hot and dry. These chemicals must be tested under other climatic conditions before their true values as insecticides in corn-borer control can be established.

TABLE 9. CONTROL OF CORN BORERS IN DENT CORN SPRAYED WITH SPECIFIED FLUORINE COMPOUNDS.[1] THIS CORN HAD A POPULATION OF APPROXIMATELY 30 LARVAE PER 100 PLANTS

Killing agent	Number of applications	Number of plots	Average kill Per cent
Barium fluoride	one	five	79
Manganese fluoride	one	five	64
Magnesium fluoride	one	five	52
Lead fluoride	one	five	63
Copper fluoride-sodium fluoride	one	five	49
Potassium fluoaluminate	one	five	72
Same with silica	one	five	89
Potassium fluosilicate	one	five	90
Sodium fluoaluminate	one	five	76
Same with silica	one	five	83
Barium fluoaluminate	one	five	70
Magnesium fluoaluminate	one	five	89
Strontium fluoaluminate	one	five	79

[1]Supplied by the Insecticide Division of the Bureau of Chemistry and Soils through the courtesy of Dr. Roark.

SUMMARY

Power sprayers and hand dusters have proved satisfactory for making applications of insecticides for the control of the European corn borer. The tests have been made in commercial fields under conditions that prevail in corn growing. The plots and the number of plants used as samples have both been large. An insecticide when used as a dust has mostly made a lower kill than when used as a spray. On the other hand, insecticides that injure corn have caused the most injury as sprays.

The various stabilizers, carriers, diluents, adhesives, spreaders, and activators have not greatly improved the insecticides with which used.

Lead arsenate does not cause a high mortality unless applied in excessive quantities. Calcium arsenate is no better than lead arsenate. Some samples of barium fluosilicate are very toxic to corn while others are not; mostly the kill is good but the corn is more or less injured. Calcium fluosilicate has consistently made satisfactory kills with a minimum of injury to corn. Sodium fluosilicate consistently made high kills which, however, were always accompanied by serious injury to the treated corn. Nicotine has not proved sufficiently toxic in the tests to justify its use. Talc in the comparatively few tests made has not consistently produced high kills. Thirteen fluorine compounds tested under the hot, dry climatic conditions of 1930 made very satisfactory kills with one application.

PRESIDENT FRANKLIN SHERMAN: Next is a paper by W. A. Baker and Ralph Mathes.

PYRAUSTA NUBILALIS HUBN. HANDLING OF SINGLE-GENERATION LARVAE TO SUPPLY PARASITE DATA

By W. A. BAKER and RALPH MATHES, *U. S. Bureau of Entomology*

ABSTRACT

For reducing mortalities in effecting a parasite recovery program for the European corn borer, fall collections of larvae of the single-generation strain should not be made prior to the borers entering hibernation. When collected, the borers should be placed under storage conditions favorable for dormancy. The hibernating borers should be allowed to remain under these conditions without contact moisture until the last of April. After this time, they may be placed under developmental conditions with weekly applications of contact moisture.

One of the most important phases of a parasite project, entailing the introduction and establishment of parasitic enemies of an insect in a new environment, is concerned with the field status of the parasites in their changed localities. Accordingly, particular emphasis has been placed on the development of an efficient recovery technique as applied to the European corn borer, involving the collection of borers under varied field conditions and their subsequent rearing in the laboratory.

The value of any data appearing from laboratory rearings of field-collected borers is limited by host and parasite mortalities experienced under artificial environments in which they must be handled in the laboratory. For this reason, in the single-generation area of the Middle West four factors that affect mortality have been carefully studied in the vicinity of Monroe, Mich., for three seasons and the results of the observations of 1929–1930 are contained in this paper. These factors are

as follows: (1) Borer development at time of collection, (2) storage conditions, (3) length of storage period, and (4) moisture requirements.

RELATION OF BORER DEVELOPMENT AT TIME OF COLLECTION TO MORTALITY AND PUPATION. A series of ten weekly and four monthly collections were utilized to determine the optimum date for fall collections of borers. The weekly collections, containing approximately 150 borers each, were started August 6, 1929, and continued until borers entered hibernation. The monthly collections, of approximately 200 borers each followed immediately and contained hibernating individuals only.

All borers were isolated in 2-inch shell vials fitted with copper screen caps. They were then placed in the store-room where temperature conditions were comparable to those outdoors. The larvae in the early collections were supplied with sections of green string beans until full-fed, which stage of development was reached in most instances by September 23. The beans were then replaced by strips of blotters, and the borers supplied each month with contact moisture.[1] The borers in later collections, when full-fed, were isolated immediately on blotters without further access to food.

Test lots introduced into the incubator-room at varying intervals indicated that by February 17 all material placed in storage had undergone a physiological change sufficient to prepare them for developmental stimuli without experiencing undue mortality. Accordingly, on this date the weekly and monthly collections were removed from the store-room and placed in the incubator-room to end the diapause. This diapause is apparently necessary for the normal development of this insect.[2] A constant temperature of 80° F. and a relative humidity of 70 per cent were maintained in the incubator-room. The application of moisture was continued, although more frequently (semi-weekly) to counteract increased evaporation that occurred in the new environment.

Table 1 shows four more or less irregular planes of mortality. The first plane has a high mortality and includes the first four collections from August 6 to August 26 inclusive. The mortality trend in this plane is gradually downward, although the mortality on August 19 and 26 is somewhat greater than on August 12. The next collection, on September 2, shows a decided drop in mortality to the second plane, which includes the three collections from September 2 to September 16 inclusive.

[1]By contact moisture is meant the application, by means of a fine-stream spray, of approximately 0.025 oz. of water to each individual borer treated.

[2]1927. Babcock, K. W. The European Corn Borer, *Pyrausta nubilalis* Hübn. 1. A discussion of its Dormant Period. Ecology, Vol. VIII, No. 1 pp. 45–59.

The mortality trend in this plane has a very slight trend downward. The next collection, on September 23, shows a decided drop in mortality to the third plane, which includes collections made September 23 and 30. The mortality in this plane is the same for both collections. The next collection, on October 7, shows another decided drop in mortality to the fourth plane, which includes the collections from October 7 to January 24. With the exception of the high mortality suffered by the collection of November 24, probably the result of excess mechanical injury, the mortality in all the collections of this plane is quite uniform and without definite trend.

TABLE 1. RELATION OF BORER DEVELOPMNT AT TIME OF COLLECTION TO MORTALITY AND RATE OF PUPATION, MONROE, MICH., 1929–1930

Date of collection	Number of specimens	Stage of development when collected	Days in incubator to break up hibernation: Days to first pupa	Days to last pupa	Mean days to pupation	Percentage of larval mortality
8/6/29	135	4th and 5th instars	17	73	45.57	33.33
8/12/29	149	" "	17	85	46.26	20.13
8/19/29	145	" "	21	85	46.21	27.58
8/26/29	150	" "	24	92	51.26	25.66
9/2/29	146	last instar	24	85	48.38	16.43
9/9/29	117	"	24	85	46.84	15.40
9/16/29	131	"	7	81	49.06	15.26
9/23/29	149	full fed	28	95	50.81	8.72
9/30/29	149	"	24	102	50.58	8.72
10/7/29	150	hibernating	24	85	48.68	4.00
10/24/29	198	"	21	85	46.05	4.04
11/24/29	195	"	17	92	48.39	10.76
12/24/29	196	"	24	99	49.11	6.63
1/24/30	200	"	21	112	48.62	5.50

All of the above borers were placed in store-room when collected, and on 2/17/30 were removed to the incubator-room for purposes of breaking up hibernation.

It is probable that these four planes of mortality can be correlated with the fact that the borers were in different stages of development when collected. The first plane included many borers which were not in their last instar; the second plane included, for the most part, borers which had reached their last instar but were not full-fed; the third plane included mostly full-fed borers prior to the time they entered hibernation; and the fourth plane included mostly hibernating borers.

Some of the mortality which appeared in the earlier collections and did not occur in the later ones probably resulted from conditions in the field prior to the date the later collections were made. However, the greater susceptibility of immature borers to injuries resulting from collection, change in environment, and the increased handling necessitated by laboratory feeding is undoubtedly responsible for most of the increased mortality. It is also evident that time of collection has little or no

influence on the length of time required to break up the diapause after borers are removed to the incubator-room. The amount of labor necessary to care for early collections is comparatively large because of the additional work required for feeding. For these reasons it seems advisable, whenever possible, to delay fall collections until the borers are just entering hibernation.

RELATION OF DIAPAUSE TO LABORATORY TECHNIQUE. *Conditions Provided for Dormancy.* To determine adequate storage facilities a series of experiments were conducted involving the use of four separate environments as follows: (1) Insectary, (2) store-room, (3) outdoors, and (4) incubator-room. Borers to be utilized in these experiments were collected in the field September 16, 1929, and disposed of as follows: 548 in the insectary, 594 in the store-room, 574 outdoors, and 917 in the incubator-room. At this date the borers were considered full-fed, and consequently were placed on blotters and supplied with moisture. They were allowed to remain in their respective places until February 17, 1930, when, for reasons previously discussed, those borers in the insectary, store-room, and outdoors were also placed in the developmental environment as represented by the incubator-room.

Hygrothermographs were placed in all environments except the insectary for the recording of conditions of temperature and relative humidity throughout the observation period. Observations made at intervals in the insectary showed the general trend of temperature and humidity conditions obtaining there as compared with the other environments. Analyzing temperature and humidity conditions in these four places (Table 2) we find that the greatest fluctuations in both temperature and humidity took place outdoors with sharp peaks occurring in each. The fluctuations, although not so pronounced, were next greatest in the insectary, and least in the store-room. These variations do not apply to the incubator-room, in which both temperature and humidity were maintained as constants. The mean daily temperature for the period of storage is highest in the incubator-room, next highest in the insectary, third highest outdoors, and least in the store-room. The mean daily humidity for the period of storage is highest for the store-room, next highest outdoors, third highest in the incubator-room, and least in the insectary.

Table 2 shows only a slight difference in the percentage of larval mortality for those borers that were carried in the store-room and those outdoors. Those placed in the insectary show a slightly higher mortality, which is probably a result of the lower mean humidity. The mean days required for breaking up hibernation after the borers were removed to

TABLE 2. EFFECTS OF ARTIFICIAL ENVIRONMENTS ON LARVAL MORTALITY AND PUPATION, MONROE, MICH., 1929–1930

Date of collection	Number specimens	Place of storage prior to forcing	Average daily temperature and humidity for period of storage						Days in incubator to break up hibernation				
			Temperature			Humidity			Date borers were removed from storage to incubator	Days to first pupa	Days to last pupa	Mean days	Percentage of larval mortality
			Maximum	Minimum	Mean	Maximum	Minimum	Mean					
9/16/29	594	Store-room	38.98	30.33	34.66	82.68	79.75	81.21	2/17/30	17	94	47.22	14.30
9/16/29	574	Outdoors	43.69	23.92	38.80	83.16	63.71	73.43	2/17/30	10	105	49.33	15.33
9/16/29	548	Insectary	——	——	——	——	——	——	2/17/30	17	101	47.87	20.25
9/16/29	917	Incubator	80.00	80.00	80.00	70.00	70.00	70.00	on collection	124	326	115.39	75.46

the incubator-room is practically the same for all three places. The borers carried in the incubator-room for the entire experimental period, however, suffered an extremely high mortality, and required an exceedingly long subjection to developmental conditions to complete their development.

These results substantiate the belief that fall collections of full-fed single-generation borers cannot successfully be placed, immediately on collection, under temperature and humidity conditions that ordinarily promote rapid development. The physiological constitution of *P. nubilalis* larvae seems to demand an intervening dormant period accompanied by conditions of temperature and humidity fairly comparable to those present in the field for that period. (Babcock, '27.)

The store-room stands out as the most desirable place for the storage of fall-collected borers during their natural hibernating period. It has in its favor slight margins in both mortality and mean length of time to pupation. Labor in handling is reduced as a result of the minimum requirements for application of moisture under relative humidity conditions that prevail in this environment, and the easy accessibility of the borers to observation while in storage.

Length of Storage Period. It is of primary importance to know when to force (i. e., subject larvae to developmental conditions as provided in the incubator-room) fall collections of *P. nubilalis* larvae so that a minimum amount of larval mortality will result. A series of experiments were inaugurated to supply this information, utilizing eleven allotments of approximately 200 borers each, to be forced at intervals of one month.

All material to be used for the last eight months of forcing, October 24, 1929, to June 24, 1930, inclusive, was collected on October 24, 1929, to eliminate as far as practicable the time -of-collection factor. All of this material, with the exception of the indicated allotment on October 24, was placed in the store-room to supply the borers with uniform conditions of temperature and humidity prior to forcing. The material used for forcing on August 24 and September 24, 1929, was collected from the field the day of forcing. All borers used in these experiments were isolated in vials, and, except for the allotment collected August 24 which was supplied with food until full-fed, all were placed on blotters, and given contact moisture the day they were collected.

Upon examining Table 3 we find that the highest larval mortality occurred in those allotments subjected to outdoor conditions for the shortest period of time prior to forcing. The trend of mortality is irregularly less as this period of time increases, being but 0.50 per cent in the last allotment forced June 24, 1930. The first allotment forced, which

was placed in the incubator August 24, required the greatest mean number of days to break up hibernation, and later allotments forced present a uniform downward trend. The last allotment, which was forced on June 24, 1930, required a mean of but 9 and a fraction days to pupation. Data from these experiments indicate that under conditions generally prevalent in the Middle Western area fall-collected borers should not be removed from the hibernating enrivonment in the store-room for purposes of forcing prior to April 24.

TABLE 3. LENGTH OF STORAGE PERIOD IN RELATION TO BORER MORTALITY AND PUPATION, MONROE, MICH., 1929–1930

Date of collection	Number of specimens	Place of storage prior to forcing	Date forced	Days in incubator to break up hibernation: Days to first pupa	Days to last pupa	Mean days	Percentage of larval mortality
8/24/29	100	Not stored	8/24/29	105	208	157.62	73.00
9/24/29	100	" "	9/24/29	81	224	137.13	71.00
10/24/29	195	" "	10/24/29	47	228	105.22	23.70
10/24/29	195	Store-room	11/24/29	40	183	69.22	7.17
10/24/29	196	" "	12/24/29	31	108	57.25	13.26
10/24/29	199	" "	1/24/30	25	97	46.92	8.54
10/24/29	198	" "	2/24/30	10	98	41.64	7.07
10/24/29	199	" "	3/24/30	18	91	40.65	8.54
10/24/29	199	" "	4/24/30	10	60	34.15	7.03
10/24/29	199	" "	5/24/30	5	58	19.35	1.50
10/24/29	200	" "	.6/24/30	4	34	9.86	.50

CONTACT-MOISTURE REQUIREMENTS. A series of experiments were conducted to supply information as to the frequency necessary in applying uniform quantities of moisture to isolated borers in certain types of environment. Two environments were selected, the store-room and incubator-room, the former possessing conditions very favorable for hibernating borers, and the latter possessing conditions favorable for rapid development and the breaking up of the diapause.

In the Store-room. Four lots of borers of 200 each, collected October 24, were isolated in shell vials as previously described. Uniform applications of moisture were applied to the first lot twice a week, to the second lot once a week, and to the third lot once a month, and no moisture was supplied to the fourth lot. The blotting paper in each vial of the fourth lot was slightly dampened prior to isolation of the borers to eliminate dehydrating possibilities of the dry blotters. On February 17, 1930, all lots were removed to the incubator-room and given contact moisture twice a week until all borers had pupated or died.

Table 4 reveals a high larval mortality in the allotment of borers that were given moisture applications twice a week. This high mortality is

probably a result of mechanical injury produced by freezing and thawing induced by the presence of excess water accumulated from the frequency of moisture applications. Aside from this mechanical injury, which was not noticeable in any of the other lots, frequency of moisture applications on material placed in the store-room seems to have no appreciable effect on the borer mortality. This is evidenced by the lack of any significant mortality trend, or variation in the days required to end the diapause, with relation to the frequency of moisture applications.

TABLE 4. EFFECTS OF VARIOUS FREQUENCIES OF UNIFORM APPLICATIONS OF MOISTURE IN THE STORE-ROOM ON LARVAL MORTALITY AND PUPATION, MONROE, MICH., 1929–1930

Date of collection	Number of specimens	Application of contact moisture	Days in incubator to break up hibernation: Days to first pupa	Days to last pupa	Mean days	Percentage of larval mortality
10/24/29	196	Semi-weekly	21	108	44.78	28.06
10/24/29	196	Weekly	10	91	44.92	3.60
10/24/29	199	Monthly	21	80	43.33	7.53
10/24/29	197	No moisture	21	129	43.59	2.03

All of the above borers were placed in the store-room when collected; on 2/17/30 they were removed to the incubator-room for the purpose of breaking up hibernation.

In the Incubator-room. Four lots of 200 borers each, collected April 8, 1930, were isolated as previously described and placed in the incubator-room. Uniform applications of moisture were applied to the first lot twice a week, to the second lot once a week, to the third lot once every two weeks, and to the fourth lot once every three weeks.

TABLE 5. EFFECTS OF VARIOUS FREQUENCIES OF UNIFORM APPLICATIONS OF MOISTURE IN THE INCUBATOR-ROOM ON LARVAL MORTALITY AND PUPATION, MONROE, MICH., 1929–1930

Date of collection	Number of specimens	Application of contact moisture	Days in incubator to break up hibernation: Days to first pupa	Days to last pupa	Mean days	Percentage of larval mortality
4/8/30	198	Semi-weekly	22	105	45.13	8.08
4/8/30	197	Weekly	28	84	46.13	5.58
4/8/30	198	Biweekly	21	98	48.07	8.58
4/8/30	199	Triweekly	28	98	54.89	10.55

All borers were placed in incubator-room when collected for the purpose of breaking up hibernation.

An examination of Table 5 shows that the least mortality was incurred by the lot given moisture once a week. Either more frequent or less frequent applications of moisture resulted in correspondingly higher mortality. The mean number of days to pupation seems to be in direct proportion to the frequency of moisture applications, being least in the lot given moisture twice a week and greatest in the lot given moisture but once every three weeks.

The pupation graphs (Fig. 25) clearly depict the immediate effect moisture applications have upon the rate of borer pupation. Semiweekly and weekly applications show regular pupation curves; biweekly and tri-

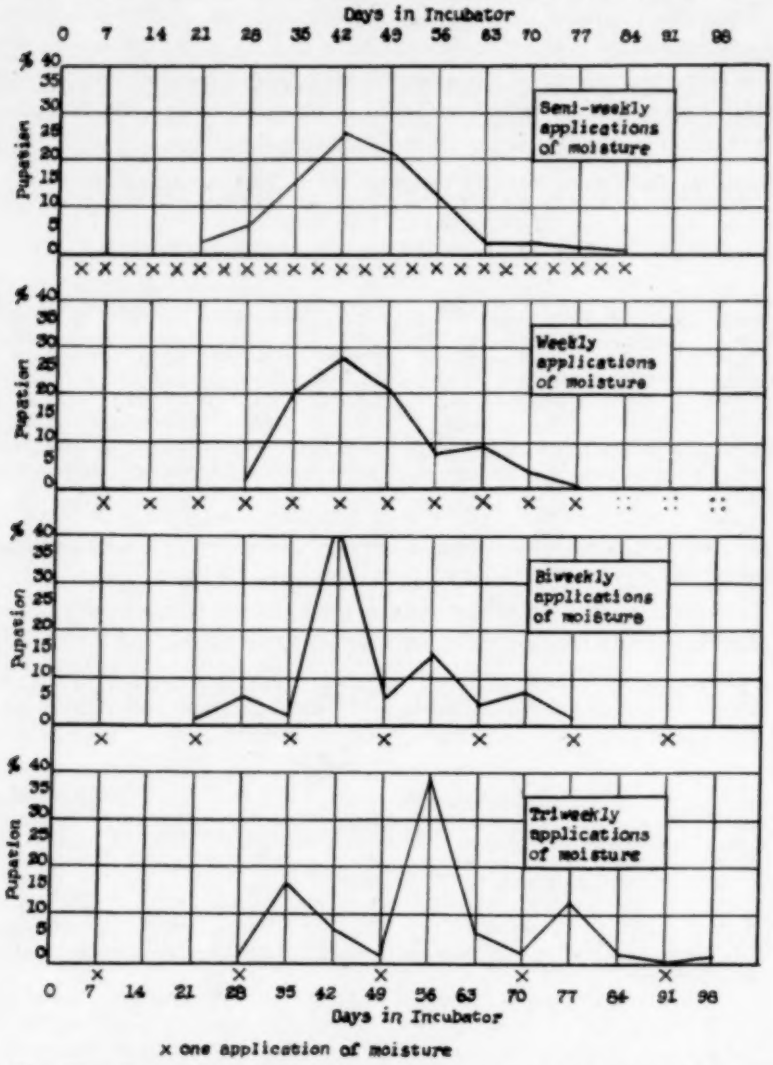
Days in Incubator
0 7 14 21 28 35 42 49 56 63 70 77 84 91 98
% 40 35 30 25 20 15 10 5 0
Pupation
Semi-weekly applications of moisture
Weekly applications of moisture
Biweekly applications of moisture
Triweekly applications of moisture
Days in Incubator
x one application of moisture

Fig. 25.—The effect of various frequencies of uniform applications of moisture on the pupation of borers under developmental conditions in the incubator-room.

weekly applications show irregular curves with an acceleration immediately on application of moisture followed by marked decreases in pupation prior to applications of additional moisture.

Conclusions

1. Whenever possible, single-generation European corn borers to be obtained from the field for purposes of supplying information regarding parasites should not be collected until they first enter hibernation, which, in average seasons, is October 1. The physiological constitution of the borers at this stage of development prepares them to withstand maximum handling and changes in environment with minimum mortality. The artificial feeding of immature stages and the mortality resulting from mechanical injury inflicted during the process are thus eliminated.

2. The store-room with its cool air having a high humidity furnishes the most desirable type of environment for the storage of fall-collected, single-generation borers prior to the time they are to be placed under developmental conditions in the incubator-room. By supplying fairly optimum conditions for the necessary diapause, mortality is reduced, the mean length of time to pupation is shortened, and labor of handling is minimized.

3. The period of dormancy in the store-room to which fall-collected single-generation borers are subjected should not be terminated, for purposes of forcing, before April 24. At this date the borers have undergone a sufficient physiological change to prepare them for rapid pupation without experiencing undue mortality.

4. Applications of contact moisture to single-generation borers were unnecessary under the hibernating conditions prevailing in the store-room during the period of this study. This is evidenced by its failure to reduce mortality, or the mean days required to end the diapause, after the borers were placed under developmental conditions.

5. One application of contact moisture each week to single-generation borers placed under developmental conditions in the incubator-room is an adequate and necessary amount. This is evidenced by the resulting rapid pupation and minimum mortality.

President Franklin Sherman: Next on the program is a paper by W. E. Hinds and B. A. Osterberger.

THE SOY BEAN CATERPILLAR IN LOUISIANA

By W. E. HINDS and B. A. OSTERBERGER, *Baton Rouge, La.*

(Paper not received.)

Vice-President J. S Houser assumed the Chair.

MR. WATSON: When do they appear?

MR. W. E. HINDS: The earliest appeared this June, probably because of migrated specimens. The occurrence of caterpillars was noticed the latter part of June and on through July, becoming fairly abundant in a few fields by the end of July and increasing rapidly in August.

MR. WATSON: In northern Florida we almost escape it by early plantings.

MR. W. E. HINDS: Yes, that happens if the crop is harvested for hay or is turned under before the worms become abundant.

MR. WATSON: It is interesting to note that in the everglades neither the soy or the leaf beans are injured; the eggs are laid on peanuts. They do not do that in northern Florida.

MR. W. E. HINDS: We had no evidence that snap beans are attacked, although they were growing close to the soy beans and seemed to be in a very attractive condition.

VICE-PRESIDENT J. S. HOUSER: The next paper is by G. F. Knowlton.

THE WHEAT STRAWWORM, *HARMOLITA GRANDIS* RILEY, IN UTAH—1930[1]

By GEORGE F. KNOWLTON

ABSTRACT

The wheat strawworm, *Harmolita grandis* (Riley), is generally distributed throughout the irrigated and dry-farm wheat sections of northern Utah. The infestation in this area was moderately heavy during 1930, one-third of the culms examined in the fall being infested.

The wheat strawworm, *Harmolita grandis* (Riley), exacts a yearly toll in the dry-farm and irrigated wheat areas of Utah. Damage varies considerably in different localities, the amount of injury apparently fluctuating from year to year. Although 1930 was not a year of excessive damage, injury from the spring generation was observed in several local-

[1]Contribution from the Department of Entomology, Utah Agricultural Experiment Station.

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ities; one-third of the culms examined in the fall were infested by the immature forms of the second generation.

Examination of 140 samples of irrigated wheat, totaling 13,937 culms, showed an infestation of 33 per cent by the second generation of *grandis*. These samples were taken from nine counties in the northern part of the state. Infestation was highest in Boxelder County, the average for 22 samples being 46 per cent. The infestation in Cache County came next; 45 samples averaged 41 per cent. Weber, Utah, and Davis County infestations averaged 31, 27, and 25 per cent, respectively. Other northern Utah counties showed the following lower infestations: Tooele, 22 per cent; Salt Lake, 20 per cent; Uintah, 11 per cent; Duchesne, 1 per cent.

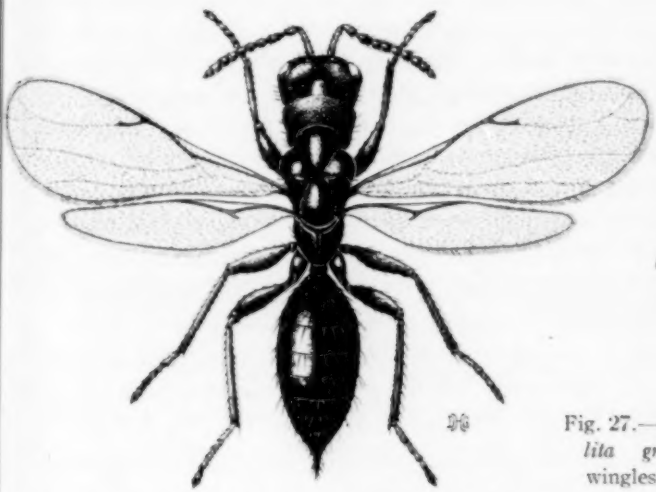

Fig. 26.—Adult female *Harmolita grandis* form *grandis*, summer form.

Fig. 27.—Adult female *Harmolita grandis* form *minuta*, wingless spring form.

Examination of 98 samples of dry-farm wheat from northern Utah counties, consisting of 9725 culms, averaged slightly less than 34 per cent infested, or scarcely 1 per cent higher infestation than the average for irrigated wheat. Infestation was highest in 26 samples from Cache County; 54 per cent of the straws were infested. Boxelder County came second; 56 samples averaged 30 per cent infested. In Tooele, Salt Lake, and Utah Counties infestations averaged 22, 20, and 18 per cent, respectively, while three samples from Weber County showed no infestation. A single sample of dry-farm wheat, received from Monticello, San Juan County, in southern Utah, showed an infestation of 1 per cent.

The larvae and pupae of *grandis* were distributed in the irrigated wheat 17.5 per cent at joint I; 39 per cent at II; 33 per cent at III; 10 per cent at IV; 0.5 per cent at V. The distribution in dry-farm wheat was 9 per cent at joint I; 31 per cent at II; 41 per cent at III; 18 per cent at IV; 1 per cent at V. Most of the infested culms contained but one larva or pupa, but in the irrigated wheat, 993 of the 13,937 culms were infested by 2 strawworms, 187 with three, and 17 with 4. In dry-farm wheat, 725 of the 9725 culms were infested with 2 strawworms, 161 with three, and 6 of the straws with 4. No culm was found to be infested with more than four strawworms. The larvae began pupating during early September, and by late October a large number of pupae were present.

The practice of allowing land to lie fallow every other year is common in most of the dry-farm wheat areas of Utah and undoubtedly does much to reduce the damage from *grandis*. Burning the stubble in the fall is practiced by a number of farmers; this, together with the abandonment of disc plows in favor of those that more completely turn under the stubble, aids in the control of this pest. Rotation of crops and fall plowing of stubble land are beneficial practices commonly carried out on irrigated farms. In dry-farm areas, many large tracts of wheat stubble are allowed to remanin standing over winter; when such fields are plowed late in the spring or during the summer, *grandis* may complete the first generation in volunteer wheat, and increase the second generation infestation on nearby farms.

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Vice-President J. S. Houser: We will now hear a paper by Leonard Haseman.

ANATOMY OF THE HESSIAN FLY LARVA

By L. HASEMAN, *Columbia, Mo.*

ABSTRACT

The Hessian fly (*Phytophaga destructor* Say) larva has besides the head twelve well defined body segments, each bearing a pair of spiracles, except the second and twelfth. The respiratory, circulatory, nervous and digestive systems are similar to those described for related dipterous larvae. The full grown larva, similar to other maggots, has its body practically filled with masses of adipose tissue.

A year ago the writer presented a short paper on "The Hessian Fly Larva and Its Method of Taking Food." This paper will deal with the general anatomy of the full grown Hessian fly larva.

The Hessian fly larva possesses a rather tough cuticula and its surface is covered with a series of small microscopic disc or platelike thickenings. These are more or less circular in outline and vary in size over the surface of the body. In some areas they take on a more or less symmetrical pattern. The hypodermis is thin.

The posterior segment of the body has two inconspicuous dorsal lobes or projections. These can be seen from the lateral and the dorsal views. Each of these lobes bears five short, blunt microscopic spines. These are mounted on low tubercles. On the ventral side of the first body segment and attached to its posterior margin is the forked spatula which is thought to be used for reversing the larva in the flaxseed case.

SEGMENTATION OF THE BODY. The small retractile head is heavily chitinized. Behind the head there is a short constricted area which appears to be the anterior portion of the first body or thoracic segment, since there is no distinct separation between it and the broader portion of the segment. The first pair of spiracles is on what the writer takes to be the first body segment. The heavily chitinized ventral spatula is attached to the hind margin of the first segment. Behind this segment are eleven distinct segments. Each of these, except the last, encloses a pair of fat bodies. The hindermost segment in some larvae also contains small fat bodies.

RESPIRATORY SYSTEM. The full grown larva taken from the flaxseed case has ten pairs of spiracles opening through low rounded tubercles. Each of the body segments, except the second and the twelfth, bears a pair of spiracles.

Each spiracle is connected with the geometrically arranged system of tracheal tubes by means of a short trachea. The tracheal system consists of a dorsal and a lateral pair of longitudinal tracheae with transverse tracheae connecting these and smaller tracheae extending to the various organs and tissues of the body. The longitudinal tracheae appear to be drawn out of line by the transverse connecting tracheae.

The dorsal pair of longitudinal tracheal tubes have six cross connections which meet on the median line where a distinct round enlargement of the uniting tubes appears. Between the ninth and tenth pairs of spiracles these cross tracheal tubes do not meet as occurs farther forward. Between the third and ninth pairs of spiracles the cross tracheal tubes and the longitudinal tubes form five similar six-sided figures. Between the first and third pairs of spiracles there are no cross connections between the two dorsal longitudinal tracheae.

Nervous System. The nervous system is inconspicuous though quite well developed. It consists of the usual paired super-oesophageal ganglia and the sub-oesophageal ganglion connected by commissures with the oesophagus passing between them. Immediately behind the sub-oesophageal ganglion is a strong nerve cord which, in transverse sections shows eleven slight enlargements or ganglia. The first three and the last three are larger than the intervening ganglia. From the last ganglion nerve cords extend to the posterior part of the body. The enlarged basal portion of the paired salivary glands lies immediately above the first five or six ganglia.

Digestive System. The digestive tract, as previously described, is quite similar to that of the various dipterous larvae which have been previously studied. It consists of a small mouth, a pharynx, and a slender oesophagus, a small spherical proventriculus and a large cylindrical ventriculus connecting with the ilium and this in turn with the colon. The digestive tract is a straight tube, except for a loop in the ilium just before it joins the colon. Opening into the mouth is the duct of the salivary gland, which in the region of the brain divides with one duct going to either large, well developed salivary gland with its expanded basal portion and cylindrical distal portion. At the point where the ilium and the ventriculus join are found a single pair of Malpighian tubes which first loop forward and then backward, ending opposite the middle of the colon. The anus is an inconspicuous ventral slit in the last segment.

Circulatory System. The circulatory system consists of the usual heart and aorta lying immediately beneath the body wall on the dorsal side of the larva. It extends from the middle of the colon or opposite the posterior end of the Malpighian vessels to a point immediately behind the brain. In the brain region it bends sharply ventrad. Its diameter is quite uniform, enlarging slightly in the region of the valves which are difficult to make out. Where it ends above the oesophagus in the brain region it is about twice the diameter of the oesophagus. Posteriorly its

diameter is about equal that of the ventral nerve cord. In cross sections large cells are found lying alongside the heart.

In the fullfed larva the heart has an average of twelve strokes per minute, though if disturbed the strokes become irregular. With each stroke most of the floating organs of the body are given a slight jerk. The heart tube is quite large in proportion to the size of the larva and its strokes are full and powerful. At times, however, the pulsation does not begin at the posterior end and travel forward normally. This may be due to pressure or other disturbance occasioned by microscopic examinations.

Reproductive Organs. The reproductive organs appear as spherical bodies on either side of and immediately behind the posterior end of the ventriculus. They lie between the fat bodies opposite the point where the Malpighian tubes join the ilium.

Adipose Tissue. In the mature larva there are eight pairs of large and usually two pairs of small, irregular masses of fat. These are so large that they fill most of the body cavity and the other organs are crowded in between them. The median segments of the body contain much larger fat bodies than either the anterior or posterior segments. The first pair of fat bodies appears in the second body segment and the last pair appears in the eleventh body segment. On the ventral side of the larva beneath the alimentary canal are seven spherical bodies closely resembling fat bodies though much less dense and they appear quite transparent with transmitted light. Again those in the anterior and posterior segments are the smaller. Along either side of the body of the larva and associated with the large paired fat bodies there are similar but much smaller bodies. There are usually two or three of these small bodies associated with each large fat body. They appear to be adipose tissue but they differ from the large masses of adipose tissue in microscopic texture.

President Franklin Sherman resumed the Chair.

President Franklin Sherman: The next paper is by G. W. Herrick and G. H. Griswold.

PARADICHLOROBENZENE AS A FUMIGANT FOR THE IMMATURE STAGES OF CLOTHES MOTHS

By GLENN W. HERRICK and GRACE H. GRISWOLD, *Cornell University*

ABSTRACT

Paradichlorobenzene has been used as a fumigant for the immature stages of clothes moths in a series of experiments extending over a period of several months. It was used at the rate of 12 ounces and of 16 ounces to 100 cu. ft. The gas of paradichlorobenzene proved toxic to the eggs, the larvae, and the pupae when confined in a tight box, trunk or closet. The immature stages were usually killed if they were subjected to the gas over a sufficient period of time. In thin, cheap, garment bags the gas did not prove very effective against the larvae. In the heavier, vapor-proof paper bags the larvae were killed.

The writers became interested some years ago in the toxic effect of the fumes of paradichlorobenzene on the larvae of the webbing clothes moth, *Tineola biselliella* Hum. Extensive experiments extending over a considerable period have been carried out but we are reporting at this time only on those conducted during the last nine months. In these investigations over 500 larvae, more than a score of pupae, and over 150 eggs were used. So far, the experiments have been carried on at ordinary room temperatures because it seemed worth while to find out what effect paradichlorobenzene would have on the larvae, the pupae, and the eggs in the environment of an ordinary household. The temperature, in the majority of cases, was recorded with a thermograph which has given a picture of the temperature conditions during the time of the particular experiment. In all of the experiments, except with the paper bags, the paradichlorobenzene was used at the rate of either 12 ounces or 16 ounces to 100 cu. ft. of space.

TYPES OF LARVAL CAGES. In the earlier experiments, the larvae were confined in fine copper wire cages, 3¾ inches in diameter and 2 inches deep. Either 5 or 10 larvae were placed in each cage with two squares of new flannel. Each cage was covered, of course, with fine muslin to prevent the escape of the larvae.

It was felt, as the work progressed, that possibly there was some reaction between the gas of the paradichlorobenzene and the copper of the cages which might have an undesirable effect on the larvae. We therefore substituted cylindrical pasteboard cartons, 3¼ inches in diameter and 1⅝ inches in depth. Ample openings were cut in the sides, the tops and the bottoms of the cartons to furnish free circulation of air and gas. Strips of fine muslin were pasted securely over the openings. This type of cage seems to answer all of the requirements for this kind of work.

TYPES OF FUMIGATION CHAMBERS. Three types of receptacles in which to place the larvae, the clothing and the paradichlorobenzene for

the fumigation experiments were used, namely, a galvanized iron box, an ordinary trunk, and an upright closet. The iron box, containing 5 cu. ft. (30 inches long, 18 inches wide and 16 inches deep) is fitted with a cover having a flange on the edge, ½ in. wide, which fits into a gutter running around the top edge of the sides and the ends of the box. If desired the gutter can be filled with oil or water, thus making an air-tight receptacle which may prove convenient for certain kinds of experimental work.

The trunk is an ordinary flat-topped one which has seen considerable use, yet is tight and in good repair. Fortunately it contains just about 5 cu. ft.

The closets in use are constructed of wall-board and are 4 ft. wide, 2 ft. deep, and 6¼ ft. high, thus containing exactly 50 cu. ft. Both closets may be called tight, but one has received two coats of paint inside and, in addition, has had all seams closed with a crack filler. In the experiments this closet has been sealed about the edges of the door with gummed paper, thus making a nearly gas-tight chamber. The other closet has been left unpainted and has not been sealed about the door in these experiments. This closet represents, in general, the type found in the average dwelling house.

EXPLANATION OF THE TABLES. The results of the fumigations can best be given by organizing the data in tabular form. The following five tables include the experimental data in a brief, concise manner and need very little explanation.

The data given in Table 1 were obtained partly from experiments carried on in the galvanized iron box (B), and partly in the ordinary trunk (T). The amount of paradichlorobenzene used each time in the box or trunk is given in grams and the manner in which the material was placed in the receptacle is indicated by the words *tin*, *loose*, and *bag*. In most of the experiments the crystals were placed in a shallow pie tin and set on top of the clothing in the receptacle. In two instances the paradichlorobenzene was scattered evenly but loosely among the garments while in three cases it was tied up in a muslin bag and placed on top of the woolens.

In several instances the larvae of the moths were placed in the cages some days in advance of the experiment, in order to give them an opportunity to become thoroughly established and normal. It was thought that possibly the larvae, when well established, might be more resistant to the effects of the gas. The results do not bear this out, although the data are too meager to draw any definite conclusion. The length of the period of fumigation seems to be more important. In all but the first

three experiments the cages containing the larvae were wrapped in a garment and placed in the midst of other garments which filled the box or trunk about two-thirds full.

TABLE 1. EFFECT OF PARADICHLOROBENZENE ON CLOTHES MOTH LARVAE WHEN CONFINED IN A GALVANIZED IRON BOX OR IN A TRUNK

	Date 1930	Amt. used in gr.	How placed	Time in days	Amt. evap. in gr.	Temp. (F.)	Number larvae used	Results* Dead	Results* Not dead	Checks* Dead	Checks* Not dead
B	3/29	17.0	Tin	6	8.0	70°–78°	6	6	0	–	—
B	3/29	22.7	Tin	6	12.2	68°–77°	6	6	0	–	—
B	4/7	17.0	Tin	4	6.4	74°–77°	10	10	0	1	9–a
B	4/7	22.7	Tin	4	10.0	74°–77°	10	10	0	1	9–a
B	4/14	17.0	Tin	3	9.0	63°–75°	10	10	0	0	10–a
B	4/14	22.7	Tin	3	6.7	65°–76°	10	10	0	0	10–a
B	4/21	17.0	Tin	4	7.7	70°–77°	10	8	2–f	0	10–a
B	4/21	22.7	Tin	4	11.6	72°–80°	10	5	3–f 2–a	0	10-a
B	4/28	22.7	Tin	4	12.4	62°–78°	10	10	0	1	9–a
T	4/28	22.7	Tin	4	14.2	62°–78°	10	5	5–a	1	9–a
B	5/5	22.7	Tin	7	14.0	68°–74°	10	10	0	1	9–a
T	5/5	22.7	Tin	7	16.8	68°–74°	10	8	1–f 1–m	1	9–a
T	5/15	17.0	Tin	7	15.6	66°–74°	20	20	0	0	10–a
T	5/26	22.7	Loose	7	all	66°–74°	10	10	0	1	9–a
B	5/26	22.7	Bag	7	7.0	66°–74°	10	10	0	1	9–a
T	6/3	22.7	Bag	7	9.0	68°–76°	10	7	3–a	3	7–a
T	6/20	22.7	Loose	7	some	70°–75°	10	10	0	1	8–a 1–m
T	7/1	22.7	Bag	7	6.7	64°–72°	10	9	1–a	2†	7–a 1–m

*a, active; f, feebly alive; m, missing.
†Both killed by parasites.

The information in Table 2 seems clear. The temperature in the closets was taken with a maximum and minimum thermometer and therefore only the extremes are known with no real picture as is given by the thermograph. The paradichlorobenzene was placed in a shallow dish which was set on a shelf near the top of the closet. The cage of larvae was suspended about two or three feet below the shelf.

TABLE 2. EFFECT OF PARADICHLOROBENZENE ON CLOTHES MOTH LARVAE WHEN CONFINED IN A CLOSET

Date 1930	Type of closet	Amt. used in oz.	How placed	Time in days	Amt. evap. in oz.	Temp. (F.)	Number larvae used	Results* Dead	Results* Not dead
7/23	Not painted nor sealed	8	Tin	8	1¼	74°–78°	10	1	3–f 5–a 1–m
8/6	Not painted nor sealed	8	Tin	43	5⅓	—	10	4	1–f 5–a
7/23	Painted and sealed	8	Tin	8	1¼	74°–78°	10	7	2–f 1–a
11/3	Painted and sealed	8	Tin	8	2⅓	70°–80°	10	9	1–f

*a, active; f, feebly alive; m, missing.

The paper garment bags used in the experiments detailed in Table 3 need some further explanation. The bags designated as thin, were purchased at the 5- and10- cent store. They cost ten cents and the paper is thin and porous. The heavy bags were purchased at a drug store and cost 75 cents each. The paper is much thicker and heavier than in the 10-cent bags, although the results were not markedly better. The vapor-proof bags were made especially for the experiments. The results are very striking and it seems feasible to manufacture such bags and place them on the market at a reasonable price.

TABLE 3. EFFECT OF PARADICHLOROBENZENE ON CLOTHES MOTH LARVAE WHEN CONFINED IN A PAPER GARMENT BAG

Date 1930	Type of bag	Amt. used in oz.	How placed	Time in days	Amt. evap. in oz.	Temp. (F.)	Number larvae used	Results*	
								Dead	Not dead
5/26	Thin	1	Loose	7	.67	70°–80°	10	1	9–a
6/3	Thin	2	Loose	7	1.75	69°–86°	10	3	7–a
6/20	Heavy	3	Bag	7	1.20	—	10	2	8–a
7/1	Heavy	3	Bag	20	1.89	—	10	6	4–f
7/8	Vapor-proof	2	Bag	13	.80	—	5	5	0
7/8	Vapor-proof	2	Bag	13	.86	—	5	5	0
7/8	Vapor-proof	3	Bag	13	1.25	—	5	5	0
7/31	Vapor-proof	2	Bag	7	.50	—	10	10	0
7/31	Vapor-proof	2	Bag	7	.75	—	10	10	0

*a, active; f, feebly alive.

In the first two experiments, the paradichlorobenzene was thrown in loose and fell to the bottom of the bag. In the remaining experiments the crystals were tied up in a piece of thin muslin. It seems evident that more of the crystals evaporate when they are loosely scattered. The temperature in all cases was that of the office in which the bags hung and, since these experiments were carried on from the latter part of May to the latter part of July, the temperature was fairly high—somewhat low at night but high during the day. In all cases the larvae were in the small pasteboard cartons and usually suspended about half way down from the top of the bag. The paradichlorobenzene, when put in loose, fell to the bottom. When tied in muslin it was suspended part way down. The dimensions of these bags are such that, when they are expanded about 6 inches by the enclosed garments, each one contains approximately 5 cu. ft.

The experimental data for the pupae are meager, but very suggestive. Table 4 needs no explanation. It should be noted that checks were maintained throughout.

TABLE 4. EFFECT OF PARADICHLOROBENZENE ON CLOTHES MOTH PUPAE WHEN CONFINED IN A TRUNK

Date 1930	Amt. used in gr.	How placed	Time in days	Amt. evap. in gr.	Temp. (F.)	Number pupae used	Results* Dead	Results* Not dead	Check* Dead	Check* Not dead
5/15	17.0	Tin	7	15.6	66°–74°	4	4	0	0	3–e 1–m
6/20	22.7	Loose	7	Some	70°–75°	6	6	0	0	6–e
7/1	22.7	Bag	7	6.7	64°–72°	5	5	0	0	5–e

*e, emerged; m, missing.

In Table 5 are given what data we have up to the present on the toxic effect of paradichlorobenzene on the eggs of clothes moths. In the first three experiments the fertility of the eggs was not definitely known. The eggs were taken from those laid by various moths in shell vials. Eggs, however, laid by this same group of moths at the same time and kept as checks hatched in a normal way. We are probably warranted in assuming that the eggs used were fertile, but we are not positive.

TABLE 5. EFFECT OF PARADICHLOROBENZENE ON CLOTHES MOTH EGGS WHEN CONFINED IN A TRUNK

Date 1930	Amt. used in gr.	How placed	Time in days	Amt. evap. in gr.	Temp. (F.)	No. eggs used	Results* Hatched	Results* Not hatched	Fertility
4/28	22.7	Tin	4	14.2	62°–78°	26	0	23 3–m	Unknown
5/5	22.7	Tin	7	16.8	68°–74°	18	0	18	Unknown
5/15	17.0	Tin	7	15.6	66°–74°	45	0	45	Unknown
6/20	22.7	Loose	7	Some	70°–75°	26	0	26	Known
6/20	22.7	Loose	7	Some	70°–75°	25	0	25	Known
7/1	22.7	Bag	7	6.7	64°–72°	21	0	21	Known
7/1	22.7	Bag	7	6.7	64°–72°	13	0	13	Known

*m, missing.

The eggs used in the last four instances were laid by four different moths. The eggs laid by a moth one day were taken for the fumigation while the eggs laid by the same moth the next day were retained as checks. Since the check eggs hatched, we are probably warranted in considering that the fumigated eggs were also fertile.

In order to determine the toxic effect of the gas on the larvae, the pupae, and the eggs, two examinations were made, one at the close of the fumigation, and the second after a week or ten days had elapsed. The results given in the tables are those obtained from the final examination.

REMARKS. It is certainly not too much to say that the experimental evidence is rather clear that the fumes of paradichlorobenzene at the temperatures indicated are toxic to the eggs, the larvae, and the pupae of clothes moths. It is also evident that infested clothing stored in tight boxes, trunks, closets and even in paper bags of the right type, may be

surely protected by the use of paradichlorobenzene for, under such conditions, the different stages of the moth may be killed in a comparatively short period of time.

Much remains to be done. Experiments must be conducted under controlled conditions of temperature in order to determine, if possible, the conditions under which the gas will be most effective. Work is also under way with other materials.

PRESIDENT FRANKLIN SHERMAN: W. P. Flint will now present his paper.

PROTECTING STORED GRAIN FROM INSECTS BY THE USE OF OILS

By W. P. FLINT, *Chief Entomologist, State Natural History Survey, Urbana, Ill.*

Because of the difficulty encountered in fumigating seed corn and grains to protect them from insect injury, experiments have been carried on for several years in Illinois to try and develop a method which could be easily applied by the average seedsman or farmer. Apparently such a method of protection has been found in the use of certain oil emulsions.

In the course of this series of experiments, which included a number of dusts and liquid dips, it was found that nearly complete protection from stored grain insects could be obtained by dipping ears of shelled corn in certain oil emulsions at rather high dilutions. These tests were carried on during a period of over three years and many of them repeated several times, subjecting the treated corn to conditions where the most severe infestation could occur. This is shown by the almost complete infestation of the checks in all cases. The following table gives a summary of the results obtained with several of the most promising orchard oil sprays used to protect seed corn from insect injuries. Detailed results of these tests are given in Illinois Agricultural Experiment Station Bulletin 359.

TABLE 1

Treatment	Total grains	Infested grains	Infested grains
	No.	No.	Per cent
Homemade boiled lubricating oil emulsion (1–10)	9200	394	4.28
Homemade boiled lubricating oil emulsion (1–8)	1143	103	9.0
Homemade boiled lubricating oil emulsion (1–15)	4092	1239	30.3
Volck (1–10)	9057	261	2.88
Volck (1–12)	1365	200	14.7
Dendrol (1–10)	1000	5	.5
Check (untreated corn)	8803	8768	99.6

The two series of tests on small grains have not shown in most cases a good degree of protection although some protection was obtained.

Several attempts have been made to find out just how or why the diluted orchard oil sprays protect grain from insect infestation. Apparently this protection is due to the thin film of oil which is formed around the corn kernels. A series of tests now under way tend to prove that this is the case and this is further indicated by the effect of treatments on shelled corn. Shelled corn treated and placed in trays and left undisturbed in rooms where stored grain insects were present, very little infestation of the grain occurred. When the corn was allowed to dry in the trays and the trays then thoroly shaken, rubbing one grain violently against the other and then setting away in the rooms for several months showed nearly 50% of the grains infested. Mr. H. E. McClure, student assistant, who has had direct charge of part of this work, ran a series of tests in which kernels of corn glued to cardboard strips were inserted in test tubes. A number of adult stored grain insects were placed in these tubes. In the tubes where larvae were placed with the treated grain, infestation occurred in all cases. In tubes where adults were placed with the treated grain, a very few of the kernels became infested, while in the untreated checks, nearly 100% infestation occurred. In the tubes where eggs were placed with the treated grain, no infestation whatever occurred while the check corn with which eggs were placed was heavily infested. The film of oil apparently prevents the very young, newly hatched larvae from entering the grain. If left undisturbed this effect persists for several months or longer. It is probable that in the tests where the adult insects were placed with the corn, that these adults in moving about in the tubes had rubbed the corn in some cases sufficiently to break the film and this might account for the small percent of infestation occurring in these tubes.

All of the tests carried on at Illinois thus far have been with oils of a viscosity of approximately 100. It is possible that oils of higher viscosity may be more valuable for this work.

Only a single small feeding test with larger animals has been carried out. No harmful results came from these tests and the treated corn was just as palatable as the untreated. A larger series of tests are now under way and it is impossible to make any definite statement regarding the feeding value of the treated corn. If an oil can be found which will not affect the feeding quality of the treated corn or other grains, this method of protecting grains certainly has very large possibilities and may be of great value in the warmer parts of the world where stored grain insects are extremely abundant and destructive.

MR. G. W. HERRICK: How do you suppose that plan would work with loose wheat, for example, a foot or two deep over a wide floor?

MR. W. P. FLINT: I cannot answer that question. We have some tests under way at the present time. I do not expect that we will get as good a degree of protection as we have obtained with corn, but we may.

PRESIDENT FRANKLIN SHERMAN: We will now listen to a paper by T. J. Headlee.

THE DIFFERENTIAL BETWEEN THE EFFECT OF RADIO WAVES ON INSECTS AND ON PLANTS[1]

THOMAS J. HEADLEE, Ph.D., *Entomologist, New Jersey Agricultural Experiment Stations*

ABSTRACT

Electric energy propagated in an electro-static field at the rate of from 1,000,000 to 3,000,000 cycles per second with a field strength of 4,000 volts per inch can be used to destroy certain insects enclosed in the electro-static field without damage to their host plants. When, however, the electric energy is propagated at the rate of from 12,000,000 to 15,000,000 cycles per second with a field strength of 4,000 volts per inch both the insects and the plants are promptly destroyed. Thus there appears a differential in the effect of electro-magnetic waves on insects and their host plants and that frequency in their rate of propagation is apparently the primary selective factor.

The writer and Mr. Robert C. Burdette (1) showed that certain insects, representing the Hymenoptera, Diptera, Coleoptera, Lepidoptera, and Orthoptera orders, are killed when exposed to electro-magnetic waves of 12,000,000 cycles per second with an ammeter reading of about 1¾ amperes, that this deadly effect is due to the development of lethal internal heat, that nervous reaction speeds up the rate of producing this internal heat, and that the more highly specialized the nervous system of the insect the greater is the apparent speed of reaction. The intensity or field strength under which the above experiments were performed has since been shown to be:—*Apis mellifera*—1585 volts per linear inch; for *Glypta*—1410; for *Musca domestica* and *Diabrotica 12—punctata*—1570; and for *Pieris rapae* and *Periplaneta germanica*—1410.

It then became necessary to determine what phases of electro-magnetic vibration formed the controlling factors in the production of this effect. In the writer's experience this lethal effect took place only within the electro-static field formed by the aluminum plates acting as electrodes. In this electro-static field, according to information received from electrical engineering sources, the varying factors are field intensity, frequency, and possibly conduction currents. In fact, the electro-static

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

field concerned is apparently identical with the electro-static field existing between the plates of the two plate condenser. To avoid the effect of conduction currents, all experiments upon insects and plants were carried on with the insects or plants enclosed in glass tubes, which, after considerable experience, were secured free from lead. Thus it seemed that the variables concerned were all eliminated except frequency and field intensity.

A machine was secured which permitted variation in field intensity from 500 volts to 5,000 volts per linear inch, or stated in another way, with a voltage gradient ranging from 500 to 5,000 volts per linear inch. This machine also permitted a variation in frequency from about 500-000 to 20,000,000 cycles per second. This machine was so constructed as to enable the operator to vary the voltage gradient and hold the frequency constant and to vary the frequency and hold the voltage gradient constant.

TABLE 1. STUDY OF THE EFFECTS OF VARYING FIELD STRENGTHS, ADULT WORKER HONEY BEES USED AS INDICATORS

Frequency in Cycles per Second	Field strength in Volts per Inch	No. of Readings	No. of Bees used	Time in seconds to kill
5,000,000	2500	10	30	No kill in 5 minutes
5,000,000	3000	10	30	89.1
5,000,000	3500	10	30	42.0
5,000,000	4000	10	30	40.5
5,000,000	4500	10	30	27.0
5,000,000	5000	10	30	24.5
8,000,000	1000	10	30	No kill in 10 minutes
8,000,000	2000	10	30	71.9
8,000,000	2500	10	30	46.4
8,000,000	3000	10	30	34.4
8,000,000	3500	10	30	27.1
8,000,000	4000	10	30	21.5
8,000,000	4500	10	30	18.5
8,000,000	5170	10	30	17.2
12,500,000	4000	10	30	30.0
16,000,000	4000	10	30	14.6
17,250,000	500	10	30	No kill in 10 minutes
17,250,000	1000	10	30	92.2
17,250,000	1500	10	30	42.9
17,250,000	2000	10	30	34.4
17,250,000	2500	10	30	28.6
17,250,000	3000	10	30	22.1
17,250,000	3500	10	30	17.7
17,250,000	4000	10	30	14.2
17,250,000	4500	10	30	10.6

The insect chosen as the indicator was the adult worker honey bee (*Apis mellifera* Linn.) because it seemed to be an organism highly sensitive to electro-magnetic waves. The bees, enclosed in glass tubes, were suspended between the plates in the electro-static field. When in place the current was switched on, the exposure timed, the current switched off, and the bees removed. An average of three bees to each tube was used.

The first study was devoted to the effects of varying field strengths and consisted of various voltage ranges at 5,000,000, 8,000,000 and 17,250,000 cycles per second. The results of this study are set forth in Table 1.

It seems fair to say that the energy required to produce death is the product of the frequency times the field strength times time, and if such

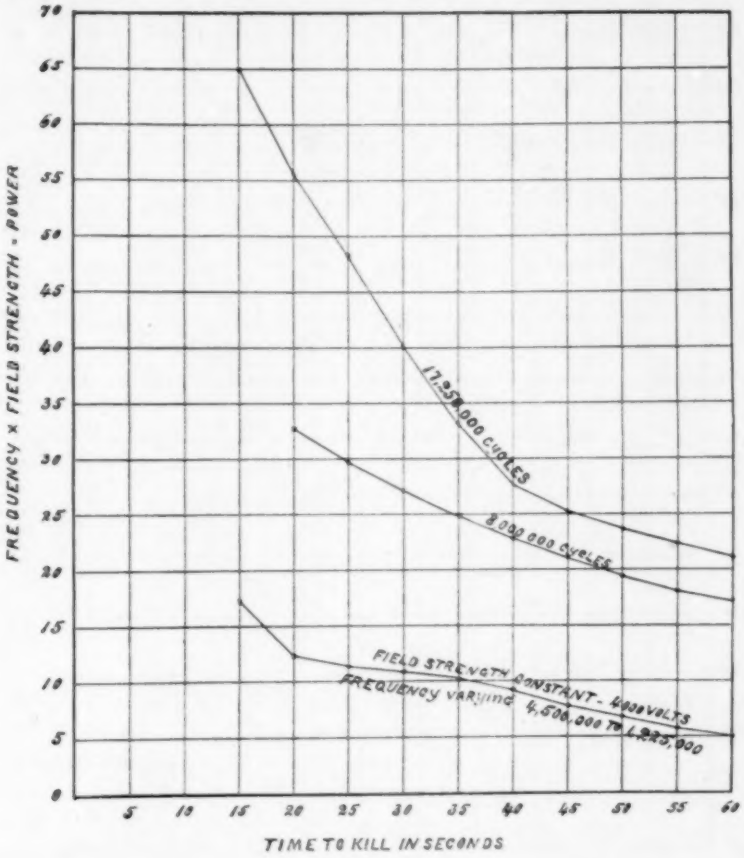

FREQUENCY × FIELD STRENGTH = POWER
TIME TO KILL IN SECONDS
17,250,000 CYCLES
8,000,000 CYCLES
FIELD STRENGTH CONSTANT - 4000 VOLTS
FREQUENCY VARYING 4,500,000 TO 1,225,000

FIG. 28

is really the case, it is obvious at once, by a study of this table, that less energy is required at 8,000,000 than at 17,250,000 and less at 5,000,000 and less at 8,000,000. It seems, therefore, likely that up to a certain point the maximum results, with a minimum expenditure of energy, can be had by running at a lower frequency. To make this matter graphically clear Fig. 28 is inserted.

This chart is constructed with the power factor as the product of frequency times field strength in volts per inch on the vertical leg and time to kill in seconds on the horizontal leg. It shows that the power re-

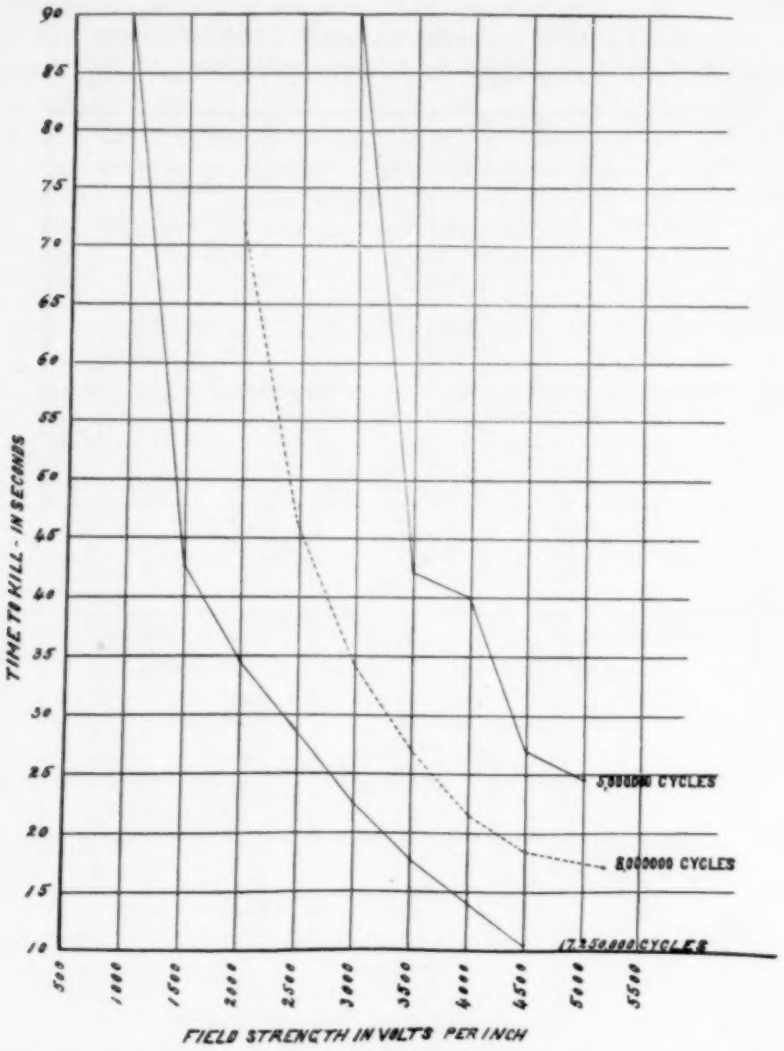


FIG. 29

quirements to accomplish kill is lowest when using the lowest frequency tried.

It then became necessary to search for what appeared to be the optimum frequency. This was done by taking a constant field strength of

4,000 volts per inch. Four thousand volts per linear inch was selected because at that figure the speed of kill was increasing rapidly in the 5,000,000, 8,000,000 and 17,250,000 frequencies. This fact is set forth in Fig. 29. The result of this study are set forth in Table 2.

TABLE 2. STUDY OF THE EFFECTS OF VARYING FREQUENCIES. ADULT WORKER HONEY BEES USED AS INDICATORS. FIELD STRENGTH CONSTANT AT 4000 VOLTS PER INCH

Frequencies	No. of Readings	No. of Bees	Time in Seconds to kill
700,000	10	30	No kill in 30 minutes
750,000	10	30	Results erratic
800,000	10	30	102.5
850,000	10	30	175.0
900,000	10	30	105.0
950,000	10	30	121.4
1,000,000	10	30	68.2
1,225,000	10	30	62.6
1,500,000	10	30	54.5
1,750,000	10	30	48.4
2,000,000	10	30	43.9
2,200,000	10	30	29.2
2,500,000	30	90	3.61–29.5–357
2,650,000	10	30	33.0
2,800,000	20	60	26.5–22.4
3,000,000	20	60	18.1–19.9
3,300,000	10	30	17.0
3,500,000	10	30	16.6
4,000,000	10	30	15.5
4,500,000	10	30	15.0
5,000,000	10	30	15.5
5,500,000	10	30	13.5
6,000,000	10	30	12.5
6,500,000	10	30	14.9
7,000,000	10	30	13.3
8,000,000	10	30	13.1
16,000,000	10	30	14.6
17,250,000	10	80	11.1

The effect of using frequencies ranging from 700,000 to 17,250,000 are shown. The results do not assume a steady character until a frequency of 1,000,000 is reached. After that point is passed the increasing speed of kill enlarges rapidly as the frequency rises until the 3,000,000 mark is reached and passed. After this point the enlargement of the speed of kill becomes small and finally somewhat erratic. This is represented graphically in the honey bee reaction line in Fig. 30.

This chart shows that there is little to be gained in increasing the frequency above 3,000,000 per second and as a matter of fact that figure is probably closer to 2,000,000. Even 1,000,000 would seem to give very satisfactory results.

Since the optimum frequency and field strength apparently ranges from 1,000,000 to 3,000,000 frequency and 4,000 volts per linear inch, the

study of the effect of electro-magnetic waves on plants was undertaken at that point. The plants employed were wheat seed and newly germinated wheat plants. The dry seed was employed in the seed studies and the young wheat plants with leaves ranging from an inch to two inches in length or more were used in the recently germinated plant studies.

In studying the effect of electro-magnetic waves upon the wheat seed in every trial 150 grains were put into a small glass tube. This tube was suspended in the electro-static field between the plates. The power was switched on, the time of exposure taken, the power switched off, the temperature of the seed mass taken with a mercury thermometer, and the seeds were placed in a moist chamber for germination. When approximately 100% of the check seed had germinated a count was made of the germination of all lots included under a specified period of exposure. The results of this study are set forth in Table 3.

This table shows that there was no damage to viability until a ten minute exposure at 5,000,000 frequency was reached and that the first complete kill came in a twenty minute exposure at 5,000,000 frequency. It further shows that the first complete kill in a ten minute exposure came at 12,000,000 frequency. It further shows that injury was done at 14,778,000 frequency at a two minute exposure and that complete kill at this frequency was obtained in a four minute exposure. A study of the mass temperatures indicates that injury to viability arrives when the mass temperature reaches about 160°F. The lower temperatures at longer exposures merely indicate that if the exposure has gone on long enough the temperatures begin to fall.

In the study of the effect of electro-magnetic waves on newly germinated wheat plants one seed was planted in each small glass tube which had been previously filled with moist soil and allowed to grow until the sprout had reached a distance of one inch or more above the soil. The tube with its wheat plant was then suspended between the plates in the electro-static field with the mouth of the tube about ¼ of an inch above the top of the plates. The power was switched on, time of exposure taken, the power switched off, the temperature of the soil surface taken with a mercury thermometer, and the plants set aside in the greenhouse to see whether they would grow or not. The results of this study are set forth in Table 4.

This table shows that killing first occurred at a fifteen minute exposure with a 2,000,000 frequency and with a soil surface temperature of about 110°F. It also shows that the plants were killed by a five minute exposure with a 5,000,000 frequency and a 120°F soil surface temperature.

TABLE 3. STUDY OF THE EFFECT OF VARYING FREQUENCIES AND CONSTANT FIELD STRENGTH ON WHEAT SEED

	Frequencies															
	750,000		1,000,000		2,000,000		3,000,000		5,000,000		6,000,000		12,000,000		14,778,000	
Minutes of exposure	Mass Temp. °F	% Germ.	Mass Temp. °F	% Germ.	Mass Temp. °F	% Germ.	Mass Temp. °F	% Germ.	Mass Temp. °F	% Germ.	Mass Temp. °F	% Germ.	Mass Temp. °F	% Germ	Mass Temp. °F	% Germ
1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	112	48.6
2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	138	6.0
3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	154	6.0
4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	174	0.0
5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	188	0.0
Check	—	—	—	—	—	—	—	—	—	—	—	—	—	—	78	94.0
5	72	95.3	78	94.0	80	94.6	88	94.0	110	94.6	102	95.3	150	31.3	—	—
10	72	94.6	78	94.6	80	96.0	92	92.0	160	54.0	150	28.0	180	0.0	—	—
20	72	94.6	82	92.0	82	95.3	94	95.3	162	0.0	180	0.0	164	0.0	—	—
40	74	96.0	82	92.6	84	97.3	94	97.3	140	0.0	146	0.0	158	0.0	—	—
60	74	96.0	86	92.0	86	96.0	98	94.6	140	0.0	162	0.0	—	—	—	—
80	74	95.3	86	91.3	90	95.3	98	96.6	140	0.0	148	0.0	156	0.0	—	—
Check	72	96.0	72	92.6	76	96.6	74	96.0	80	88.6	78	90.6	76	96.0	—	—

TABLE 4. STUDY OF THE EFFECTS OF VARYING FREQUENCIES AND CONSTANT FIELD STRENGTH ON NEWLY GERMINATED WHEAT PLANTS

Minutes of exposure	Frequencies											
	750,000			1,000,000			2,000,000			3,000,000			5,000,000		
	HSB Inches	HSE Inches	T °F	HSB Inches	HSE Inches	T °F	HSB Inches	HSE Inches	T °F	HSB Inches	HSE Inches	T °F	HSB Inches	HSE Inches	T °F
5	4.00	4.75	78	3.75	4.50	86	0.75	2.00	92	1.00	1.25	110	3.25	dead	120
10	2.75	4.00	78	1.50	2.25	86	0.50	0.75	104	1.00	3.50	102	3.00	dead	128
15	2.50	3.75	78	1.25	1.50	98	2.75	dead	110	1.00	dead	120	3.00	dead	136
20	2.00	3.25	80	2.50	2.75	90	0.50	dead	108	1.00	dead	124	2.50	dead	122
25	2.75	4.00	80	2.50	4.00	88	1.65	dead	102	1.00	dead	126	2.50	dead	138
30	2.75	3.75	80	2.15	3.00	92	0.75	dead	100	1.50	dead	118	1.50	dead	130
Check	0.75	1.50	—	1.00	2.00	84	1.25	4.00	78	1.25	3.50	72	2.50	3.75	76

HSB = Height of plant at beginning of treatment.
HSE = Height of plant at end of allowed period of growth.
T °F = Temperature in degrees Fahrenheit of soil-surface at close of treatment.

There seems to be no reasonable doubt that both the wheat seed and the newly germinated wheat plants were killed through the accumulation of a lethal temperature.

The relation between the effect of electro-magnetic waves on insects, as typified by the honey bee, and plants, as typified by wheat seed, is set forth in Fig. 30. Honey bees exposed to a frequency of 2,000,000 and a voltage gradient of 4,000 volts per linear inch are killed in less than a minute while wheat seed may be exposed to the same frequency and the same field strength for a period of eighty minutes without any injury whatever to viability. That the killing of the newly germinated wheat plants, which occurs in fifteen minutes under the same frequency and field strength, is due to soil heat and not to the development of internal heat is shown by the experiment of exposing the wheat stalk to the 2,000,000 frequency and 4,000 volts per linear inch for a period of eighty minutes without any injury whatever.

Thus there is shown to exist a very clear-cut differential between the effect of these electro magnetic waves upon the insects and upon seeds, as typified by wheat seed. There is in the writer's possession a considerable amount of corroborative data as yet unpublished leading to the same general conclusion. This appears to open the way to the possible use of electro-magnetic waves for the destruction of insects infesting stored seeds, stored grain, grain products, etc., as well as to indicate that something may be done with this agency for destroying insects that nfest green and growing plants.

Summary

1. The electro-static field existing between the two plate electrodes is apparently the only place where electro-magnetic waves are sufficiently strong to produce lethal effects.

2. The variable factors underlying these lethal effects apparently are field strength, which is commonly expressed in terms of volts per linear inch, frequency measured in terms of cycles per second, and possibly conduction currents.

3. Conduction current effects were eliminated by enclosing the organisms worked with in glass and the other two variables were controlled at will.

4. Since more power was required to produce lethal effects on insects at higher than at lower frequencies and since, on lower frequencies a field strength of about 4,000 volts per linear inch was required to bring about quick results, the study of frequency effects on both insects and plants were made at that field strength.

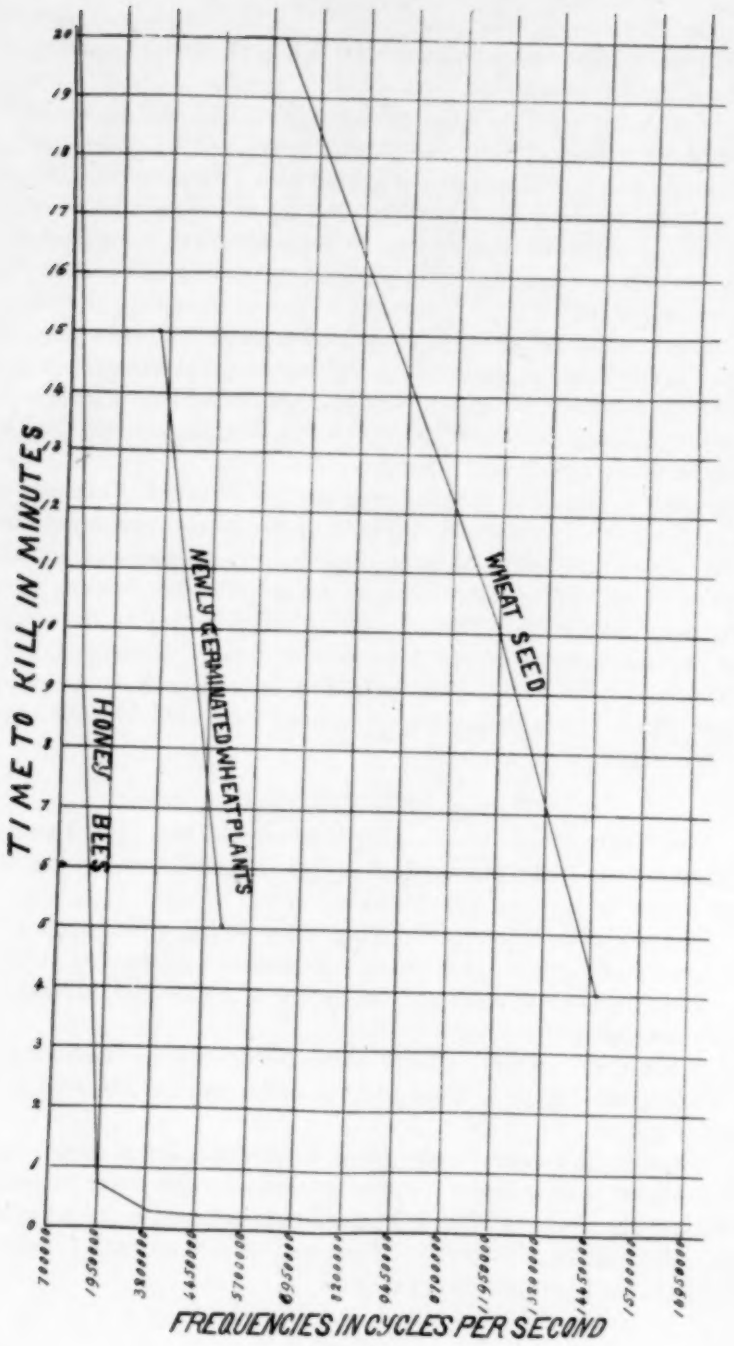

TIME TO KILL IN MINUTES
HONEY BEES
NEWLY GERMINATED WHEAT PLANTS
WHEAT SEED
FREQUENCIES IN CYCLES PER SECOND

FIG. 30

5. The optimum frequency for insect destruction makes its appearance between 1,000,000 and 3,000,000 per second.

6. At frequencies ranging from 1,000,000 to 3,000,000 per second insects are killed within a few minutes (in tests recorded in this paper in one minute or less) and plants are unhurt in 80 minutes.

7. In using electro-magnetic waves for destruction of insects there is apparently a wide margin of safety and it is apparently definitely indicated that electro-magnetic waves are worthwhile developing for insect control purposes.

ACKNOWLEDGMENT

The writer wishes to acknowledge his indebtedness to Mr. Louis Kahn, member of the engineering faculty of Rutgers University, who served as a temporary assistant during the past summer and whose knowledge of electro-magnetic wave production made it possible to maintain constant field strength with varying frequencies.

REFERENCE

1. HEADLEE, T. J. and BURDETTE, R. C. Some Facts Relative to the Effect of High Frequency Radio Waves on Insect Activity. Journ. N. Y. Ent. Soc., Vol. XXXVII, March, 1929.

PRESIDENT FRANKLIN SHERMAN: The next item is a paper by E. P. Felt and S. W. Bromley.

DEVELOPING RESISTANCE OR TOLERANCE TO INSECT ATTACK

By E. P. FELT and S. W. BROMLEY, *Bartlett Tree Research Laboratories, Stamford, Conn.*

ABSTRACT

There are many peculiarities in relation to insect attacks which have not been explained. Some are undoubtedly physiological, others may have a distinct relation to the vigor or condition of the plant, as in the case of the Hessian fly, ***Phytophaga destructor*** Say, the lace bugs of rhododendrons and azaleas, *Stephanitis rhododendri* Horv. and *Stephanitis pyrioides* Scott, respectively. Injury is also somewhat proportionate to the size and vigor of the host, as evidenced by European corn borer, *Pyrausta nubilalis* Hubn., infestations. Extended injuries by the elm leaf beetle, *Galerucella xanthomelaena* Schrank, are dependent in considerable measure upon favorable climatic conditions, these latter undoubtedly resulting in a less vigorous growth. A peculiar and unexplained physiological reaction by gipsy moth larvae, *Porthetria dispar* Linn., is also mentioned. Evidence available indicates that a number of the cambium borers, namely the bronze birch borer, ***Agrilus anxius*** Gory, the two-lined chestnut borer, *Agrilus bilineatus* Web., the hickory bark beetle, *Scolytus quadrispinosus* Say, and the cedar bark beetle, *Phloeosinus dentatus* Say.

successfully invade trees with a lowered vitality and that in the case of the first named, it is possible to stimulate growth by feeding and aid trees to actually destroy the borers. It is suggested that a uniform and satisfactory supply of moisture throughout the season and feeding to promote a vigorous growth may be valuable preventive measures in the case of certain insects at least.

It is well known that clean culture, rotation of crops and the growing of varieties of plants relatively immune to insect attack are important methods of preventing serious insect depredations. The evils of a disturbed biotic balance are evident to any entomologist who has given consideration to the general principles governing insect outbreaks. The possibilities of biological control are being explored as never before and offer much of promise in the practical control of a number of serious insect pests.

Some of the anomalies of plant resistance to insect attack have been summarized admirably by the late William Lochhead in his Economic Entomology, published in 1919 and are as follows.

"No satisfactory explanation has yet been given for the preferences many insects exhibit in their feeding habits. As examples, we are at a loss to know why in some districts the wheat midge does more damage to spring wheat than it does to fall wheat; why the Hessian fly injures certain varieties of wheat more than others; why the grape-blossom midge injures the early varieties of grapes most; why the Leconte and Kieffer pears are practically immune from the San Jose scale and the white peach scale; why the Northern Spy apple is not troubled with the woolly aphis; why the Red Dutch cabbages are free from the cabbage root maggot; why the spiny elm caterpillar and the European elm scale prefer the American elm to the imported English elm; why the European elm sawfly and the elm leaf beetle prefer the European elm to the American; why the forest caterpillar attacks the sugar maple in preference to the soft maple; why the maple scale prefers the soft maple to the sugar maple; why the apple maggot is more injurious to sweet and subacid summer varieties than to fall and winter acid varieties; why the brown mite is seldom seen on quince and apricot; and why the phylloxera is more injurious to the European vine than to the native American species."

There are numerous other peculiarities in the relation between insects and their hosts. The spruce gall aphid, *Adelges abietis* Kalt., is very local in its attack and apparently certain Norway spruces are practically immune. The spotted hickory leaf aphid, *Myzocallis fumipennellus* Fitch, develops abundantly upon certain trees and is hardly found upon others, and this is also true of the hickory leaf stem gall

aphid, *Phylloxera caryaecaulis* Fitch. A practical application of insect limitations may be made in the case of the box elder plant bug, *Leptocoris trivittatus* Say, since it has been found that the females oviposit only in the fruits of this tree, consequently staminate trees are ordinarily not infested. It is also recognized that the locust growing in shade is much less subject to attack by the locust borer, *Cyllene robiniae* Forst.

There is another phase of the insect problem which appears to have received little systematic consideration, although it is touched upon frequently in entomological literature and that is the possibility of developing resistance to insect attacks. It is well known that for some reason or other, an extreme abundance of insects is associated with reduced plant vigor and in not a few instances, it has been assumed that the unfortunate condition of the plant was a result of insect attack rather than the outcome of a condition favoring the development of insect pests. It is our belief that too little attention has been given to this phase of insect control, particularly in the case of long lived plants, such as the trees, both fruit trees and shade trees. These are not easily replaced. It is frequently impossible to grow resistant varieties. It may be possible to develop resistance to insect attack.

In the first place, to take a relatively simple example, it is noteworthy that certain grasshopper outbreaks are limited in large measure to areas where there is a sparse vegetation, this being due in considerable measure to an unfavorable environment and the effect vigorous growth has upon the development of the insect. This is evident to such an extent that poor fields of oats may be severely damaged, while those nearby in a luxuriant condition and even adjacent heavy grassy areas may contain no more than the usual number of grasshoppers. There is a biological cause for this. It is not a mere accident.

It is well known that the Hessian fly, *Phytophaga destructor* Say, develops abundantly in low areas where there is a lush growth, though wheat of the same variety escapes injury largely when growing on dry knolls. This is evidently due to physiological limitations of the insect. The late Dr. J. W. McColloch stated[1] that increased resistance of wheat to Hessian fly has been secured at the Kansas Agricultural Experiment Station by the addition of sodium silicate to cultural solutions. This is a clear case where resistance to insect attack was developed. Certain Russian workers have found that a high silica content in the cells of *Lithospermum arvense* gives protection from aphids. E. A. Andrews in the Report of the Fourth Entomological Meeting at Pusa, India records that an increase in the ratio of potash to phosphoric acid in the leaves of

[1]Kansas State Hort. Soc. Trans. 37: 202. 1924.

tea increases the resistance of that plant to attack by *Helopeltis*. Dr. McColloch also mentions the fact that one investigator found in the case of cabbage that early planting and thinning rendered the plants more capable of resisting attacks by the cabbage fly, while another advises the addition of salt peter or ammonium sulfate to the surrounding soil, thus producing stronger plants more resistant to the cabbage maggot. The studies of Mr. J. H. Hawkins in Maine (Jour. Econ. Ent. 23: 351, 1930) show that a judiciously used fertilizer stimulated growth of sweet corn and a heavy yield resulted, even though the wireworm, *Melanotus* sp., population ran into several thousands per acre[2].

It is undoubtedly true that attempts to grow plants in other than the natural environment is very likely to result in severe insect injury. This is illustrated by great damage caused by lace bug, *Stephanitis rhododendri* Horv. and *Stephanitis pyrioides* Scott. to rhododendrons and azaleas respectively, when growing in open, sunny spots. Well shaded plants, the normal environment, are rarely troubled by these pests.

It is well recognized that severe insect injury occurs only where there is an abundant infestation. It is not so generally appreciated that there may be a distinct relation between the vigor of the plant and the injury caused by a given number of insects. In the case of the European corn borer, *Pyrausta nubilalis* Hubn., for example, an infestation of five or six borers per stalk may be serious on small growing corn, such as the early bantam, while the same stalk infestation is almost negligible in the case of a rank growing variety, such as dent corn, yet the actual number of insects per stalk may be the same in both cases. In other words, there is a mechanical ratio in relation to injury and other things being equal, the larger more vigorous plants can carry a heavier infestation without serious injury than the smaller ones. This is not exactly immunity to insect attack. It is more properly expressed by the word tolerance.

There are some reasons for believing that this tolerance to insect attack, if it may be termed this, is true also of trees. Unfortunately, there are not many definite data which can be cited in support of this contention. The elm leaf beetle, *Galerucella xanthomelaena* Schrank, thrives moderately during the relatively dry hot seasons, conditions obviously unfavorable to the development of a maximum leafage, es-

[2]Since the above was presented at the Cleveland meeting, there has appeared in the January 9 issue of Science, pp. 49–50, a paper with extensive bibliography by E. P. Mumford and entitled: "Studies in Certain Factors Affecting the Resistance of Plants to Insect Pests." This is concerned largely with the factors favoring resistance and gives little additional respecting the possibilities of developing resistance.

pecially under the artificial conditions of many city streets and the closely shorn lawns. It has been assumed that weather was the important factor in determining the severity of elm leaf beetle injury and undoubtedly it has a considerable effect upon the abundance of the insect and the amount of injury caused by the pest. It is a matter of common knowledge that the weaker trees with a somewhat sparse foliage suffer more from the attacks of this insect than those producing a super-abundant leafage. It may be said that tolerance has been reduced. Though the elm leaf beetle displays a marked preference for European elms, it severely injures American elms. It is a local insect and severe damage is frequently associated with excellent, nearby winter shelters, such as church belfries and open sheds. This, however, may not be the only reason why it is rarely numerous in the open country where elms usually enjoy better growing conditions. Possibly there is more significance in the vigor of growth than appears upon the surface. The senior author recalls one moist season a number of years ago when rain favored such an abundant development of foliage that elm leaf beetle grubs were unable to make a marked impression upon the trees, and while the cool damp weather was presumably unfavorable to the development of the grubs, it is also possible that the dense foliage assisted materially in producing an environment unfavorable to the larvae. The ranker growth under these conditions may have been not only distasteful to the grubs, but even exercised an unfavorable physiological effect. It is well known, for example, that domestic cattle, particularly cows, exhibit a marked distaste for the ranker growing grasses in heavily manured spots.

A very curious reaction has been recorded by Mosher (U. S. Dept. Agr. Bulletin 250, page 27, 1915). Gipsy moth larvae, *Porthetria dispar* Linn., were fed in the summer of 1912 on the foliage of two willow trees, *Salix alba* L., at Melrose Highlands. Those supplied with the leaves from one tree fed normally, grew rapidly and in due time developed into large adults. The others grew very slowly, the larvae were small and this was also true of the adults. Nearly three times as many eggs were obtained from the first lot as from the second, although all the larvae used in the experiment were hatched from the same egg cluster. The tests were repeated in 1913 with foliage from the same trees and with larvae hatched from eggs of the previous year. The results were exactly reversed. There is a possibility that some potent factor escaped notice. The record on the face of it, suggests physiological reactions which ordinarily escape attention.

There are some definite physiological reactions in the case of leaf eating caterpillars. It is well known, for example, that the younger stages of gipsy moth larvae are unable to subsist upon a variety of foliage, which is entirely acceptable and apparently devoured with relish by those in the more advanced stages of development. These limitations at present can be determined only by experiment. It is possible that with a more refined technique, probabilities in this respect could be determined through chemical analysis.

It is well known that the results of invasion by cambium borers are roughly proportional to the number of insects attacking the trees. It is not so generally recognized that unless an infestation is too severe, it is possible through stimulating growth by feeding or watering to enable a tree to outgrow a moderate infestation by borers. This has been demonstrated in repeated instances in the case of birches moderately infested by the bronze birch borer, *Agrilus anxius* Gory. It is presumably true, though the evidence is not so clear, in the case of the two-lined chestnut borer, *Agrilus bilineatus* Web. The experience of the last 25 years has shown that vigorous hickory trees with a moderately uniform supply of moisture and a good feeding area rarely succumb to the hickory bark beetle, *Scolytus quadrispinosus* Say. The practical experience of a well known nurseryman has shown that such a simple procedure as watering will enable red cedars to drown out incipient infestations by the cedar bark beetle, *Phloeosinus dentatus* Say. These and other facts of a similar nature lead us to conclude that attention to the physical condition of a tree is of fundamental importance and is one of the phases of entomology which may well receive greater attention than has been given to it in the past. In other words, it is entirely possible in some cases at least, to develop a resistance or tolerance in trees to insect attack.

The above may easily lead entomologists into the consideration of factors which ordinarily are regarded as outside the pale of applied or economic entomology. Preventive work means a study of conditions favorable to insect depredations. It is of primary importance that a tree be in a vigorous condition. The judicious application of a fertilizer or feeding has a distinct place among measures of value in preventing or minimizing the effects of certain insect outbreaks. The permanence and distribution of the seasonal water supply may well receive consideration and while in many cases artificial watering is inadvisable, it may be entirely possible to conserve the water supply by mulching or the utilization of a low growth around the trees and thus establish a more or less permanent mulch which will approximate to some extent the

normal mulch of forest conditions. There are many low lying, normally moist fields or meadows where trees suffer greatly from drought. Proper drainage deepens the feeding area for the roots and considerably lessens the effects of drought and a subsequent danger of serious injury by insects.

There is more than a theoretical application to the above, particularly when it is recalled that in portions of the country there have been extended dry periods during the past two growing seasons. This means that many of the trees in unfavorable locations have been more or less seriously weakened by the recurring droughts. This is particularly likely to be the case with trees in low, poorly drained sections or those on the thin soil of rocky ledges. The effects show to a marked extent, though presumably not to such a great degree on trees growing along streets and in closely clipped lawns, both places where there is a wide variation and frequently a marked deficiency in the seasonal supply of moisture, due to restricted feeding areas and the almost total absence of the normal mulch of woodlands. There is a real opportunity for entomologists in the drought affected areas to anticipate the probabilities of more serious damage by leaf feeders or borers and advocate a program of feeding or drainage where necessary, which will go far toward stimulating a vigorous growth and literally developing resistance to insect attack. It is a matter of more than passing importance, since the beauty and desirability of many residential and recreational areas is dependent in large measure upon thrifty shade trees. It is well to remember that while young symmetrical trees are beautiful, they cannot begin to have the majesty and attractiveness of those which have been growing for 50 years to two centuries or even longer.

Adjournment: 12:30 P. M.

Thursday Afternoon Session, January 1

The session was called to order at 1:30 P. M., President Franklin Sherman presiding.

PRESIDENT FRANKLIN SHERMAN: The first paper on the program is by W. A. Baker and K. D. Arbuthnot.

AN INCUBATOR ROOM

By W. A. Baker and K. D. Arbuthnot, *U. S. Bureau of Entomology*

Abstract

Details of construction of hygral and thermal equipment for installation in an incubator room are given. The selection and treatment of the room are also discussed.

The need for an inexpensive insect incubation chamber, much larger than is readily available in the average incubator, to be utilized in connection with the various phases of the parasite projects on the European corn borer (*Pyrausta nubilalis* Hubn.), has been the subject of experimentation by the different investigators engaged in the parasite activities. This paper deals with the incubator room and equipment now in operation at the Field Laboratory of the Bureau of Entomology

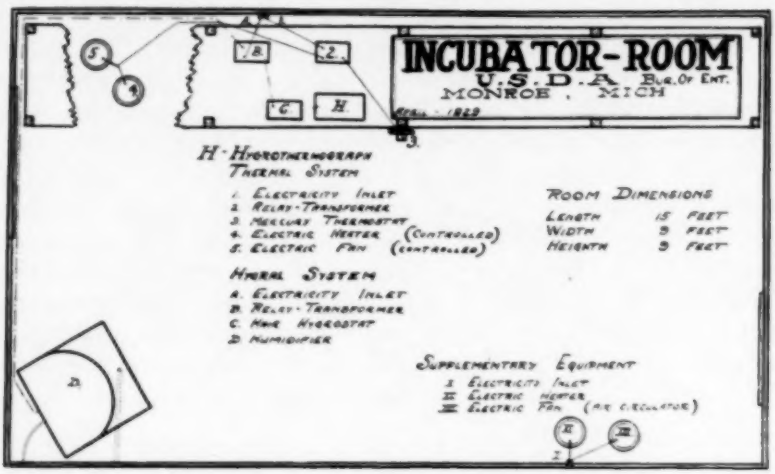


Fig. 31.—Diagram showing floor plan of incubator room with location of apparatus and dimensions

in Monroe, Michigan, in which methods devised at both the Arlington, Massachusetts, and Monroe, Michigan, Laboratories have been utilized. While incubation of the type discussed is subject to continual change and improvement, the varied application possible of the information now available makes publication of some of the accumulated data advisable.

The Incubator Room. The room under consideration (Fig. 31) contains 1,215 cubic feet of air space and the hygral and thermal systems as later specified have been designed to meet the needs of this content of

air. A temperature of 80° F. and a relative humidity of 70 per cent are maintained, as required for present projects that occupy the room. Wide variations from these points can be obtained, however, with the equipment now in use.

Insulation against conductivity of heat is the major precaution to be taken in the selection of the room to be utilized, after determining the cubical space adequate to meet the demands of the projects. An interior room which has as few openings as possible is to be preferred. Double glazed windows are supplied to reduce radiation of heat and these are equipped with awnings to divert the direct rays of the sun which otherwise seriously interfere with maintenance of moderate room temperatures. All openings in the room are lined with insulating felt. Various supplementary insulating devices may be employed, such as lining with insulating board and the application of ground cork, sawdust, etc., to exposed outer surfaces. In the average well constructed building no special treatment is required other than covering all exposed surfaces inside the room with a good grade of waterproof paint or varnish. Such treatment materially assists insulation and aids in preventing the development of many molds that normally thrive in the warm, moist atmosphere prevailing in the room.

To insure uniform conditions of temperature and moisture throughout the room, the hygrostat (Fig. 31, C) and thermostat (Fig. 31, *3*) are located as near the center of the room, vertically and horizontally, as is practicable.

The Thermal System. The thermal system (Fig. 32) is composed of four units including a mercury thermostat, a relay-transformer, a heater, and a distributor. The relay-transformer as figured is well adapted for use in a room of this type.

The mercury thermostat (Plate 13, Fig. 1) consists of a glass mercury tube (Fig. 32, *8*), 23 cm. long and 2 cm. in outside diameter, holding approximately 500 c.c. of redistilled mercury (Fig. 32, *10*). This tube is topped with an expansion tube in which the mercury rises and falls, 4 cm. long and 2 mm. in inside diameter, filled with high-grade light mineral oil (Fig. 32, *9*) as a preventer of oxidation.[1] The expansion tube is in turn topped with a flare tube 6 cm. long and 1 cm. in inside diameter, through which an adjustable platinum contactor (Fig. 32, *6*) extends into the expansion tube, making contact with the mercury. A stationary platinum contactor (Fig. 32, *11*) is inserted into the mercury

[1]Robinson, William.—Construction and Installation of a Toluol Thermostat—Ann. Ent. Soc. Amer. Vol. XXI. No. 4.

through the glass side of the mercury tube. The circuit from these two contactors is extended to a transformer, making and breaking a 6-volt circuit and operating the relay.

One hundred and ten volts are carried through the relay to the heating unit (Fig. 31, *4*), which is an electric furnace of 1,000 watts capacity. An electricf an (Fig. 31, *5*) is connected into the same circuit, which, operating with the furnace, serves to distribute the heat uniformly

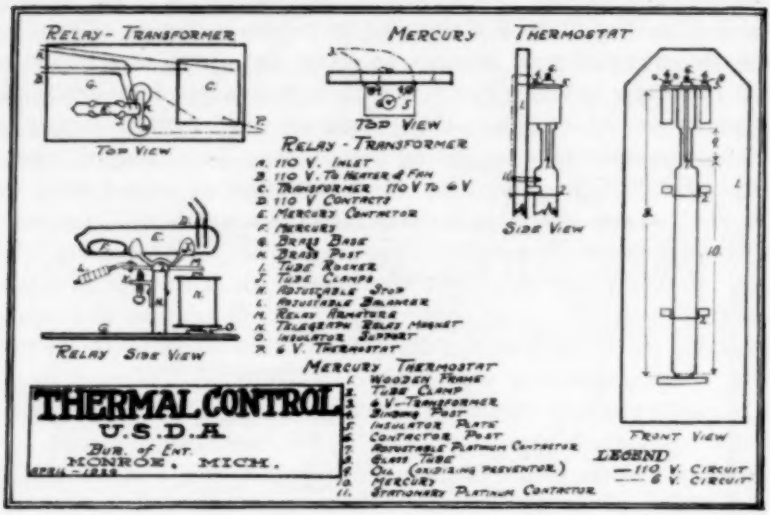


Fig. 32.—Details of thermal control system in the incubator room

throughout the room. A supplementary heater (Fig. 31, II) with fan (Fig. 31, III) is provided to insure correct thermal conditions when outside temperatures are too low for a single unit to function efficiently.

A variation in the application of the thermal system provides for cooling the room to required temperatures for the duration of high-temperature periods that occur in summer months. This is made by reversing the mercury contactor (Fig. 32, E) in the tube clamps (Fig. 32, J), so completing the 110-volt circuit through the relay at any temperature in excess of that for which the thermostat is set. The heater is then removed from the circuit and a tray fitted with an overflow placed in front of the fan. Ice blocks are introduced into the tray, and the action of the fan in circulating room air over the melting ice and cold water that fills the tray to the level of the overflow serves to hold the temperature constant as effectively in warm weather as the action of the heater does in cold weather.

THE HYGRAL SYSTEM. Regulation and maintenance of adequate conditions of relative humidity as applied to biological studies in the laboratory and general rearing and breeding technique have proved to be fully as important as similar control of temperature. With this consideration in mind, an automatic system (Fig. 31) for the control of atmospheric moisture has been devised consisting of a hair hygrostat (Plate 13, fig. 2) as the regulating unit and a humidifier (Plate 14, figs. 1 and 2) as the evaporating and distributing unit. A relay-transformer, similar to that used in the thermal system, is interposed between the hygrostat and the humidifier in order to permit the use of a low voltage current through the contact points of the hygrostat, which prevents excessive corroding, burning, and sticking of the point.

The hygrostat is operated by a strand of parallel human hairs (Fig. 33, *6*) which have been treated with ether to remove fats that would interfere with the action of atmospheric moisture on the hair. The sensitivity of the apparatus is contingent on the length of the strand, 5 inches being sufficient for regulation within 1 per cent. One end of the strand is fastened to a stationary post (Fig. 33, *8*) through a coarse adjustor (Fig. 33, *7*) and the other end to a brass tension arm (Fig. 33, *5*) one thirty-second inch thick and one-fourth inch wide tapering to one-eighth inch wide at the free end, and three and one-fourth inches long. The tension arm is attached at one end to a second stationary post (Fig. 33, *8*) and the strand fastened to the arm 1 inch from the post. A contact point (Fig. 33, *4*) is located on the free end of the tension arm and makes and breaks with a point on the end of a fine adjustor (Fig. 33, *3*) installed on a third stationary post (Fig. 33, *8*). The action of changing humidity conditions on the strand is thereby transmitted to the contact points through the tension arm.

The three stationary posts are bolted onto an insulated base (Fig. 33, *2*) permitting an electric circuit to be completed through the post supporting the tension arm, across the tension arm to the stationary point, and so to the post carrying the adjustable point. The making and breaking of the contact points of the hygrostat controls an electric current used to regulate the humidifier. When contact is made in the hygrostat its effect is to actuate a 16-inch oscillating electric fan (Fig. 33, III) with a 110-volt current supplied through the relay-transformer. The fan operates both as an evaporator and as a distributor, as it forces air through the evaporation surface (Fig. 33, I), at the same time directing a constant spray of water to the surface.

The spray is supplied by making connection with the laboratory water system (Fig. 33, II) and breaking the water up with a small disc

nozzle (Fig. 33, *4*) attached to the fan guard and oscillating with it. It is advisable to utilize warm rather than cold water when available, as it will evaporate much more rapidly. Relative humidities ranging from 90 per cent to saturation point may be readily obtained with this apparatus if water temperature is maintained above 150° F. and if one or two additional spray nozzles are coupled to the supply line.

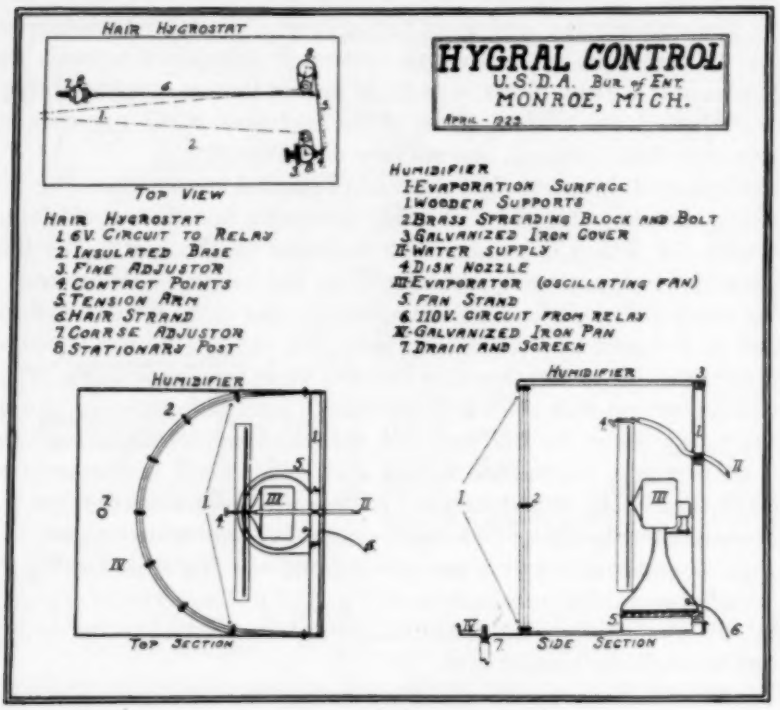
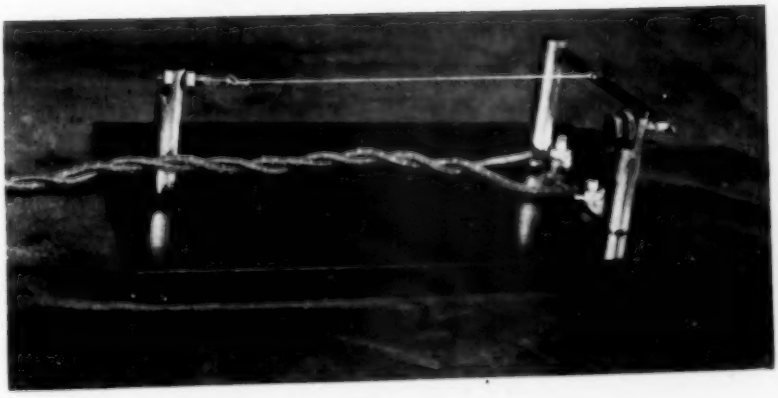


Fig. 33.—Details hygral control system in the incubator room.

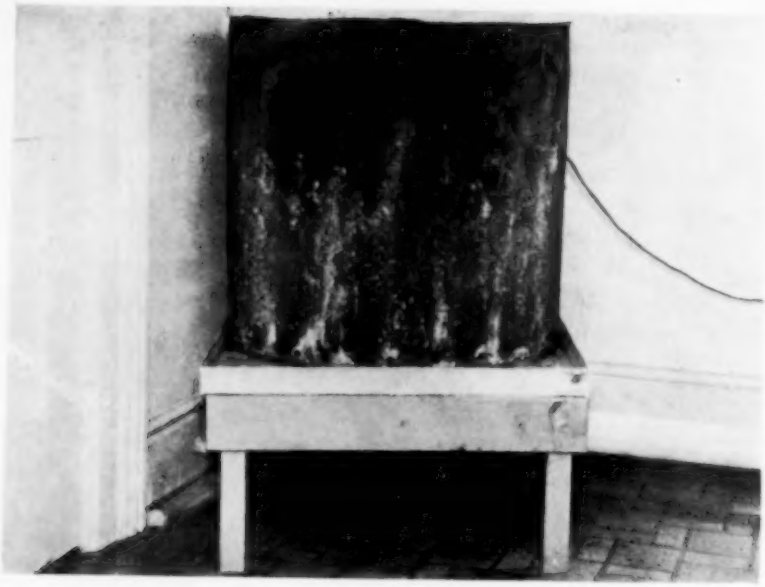
The principle involved in building up the evaporation surface is to expose the maximum amount of water surface to the action of air currents set up by the fan and, at the same time, permit the free flow of air through the surface rather than throwing it back away from the water. In the latter case, the action of the air would be similar to passing it over the surface of a pan of water, and this method is too inefficient to permit close regulation.

The surface illustrated is composed of three layers of copper screen (Fig. 33, I), each supported on one-half inch mesh galvanized wire and separated from one another, except at the ends, by one-half inch brass

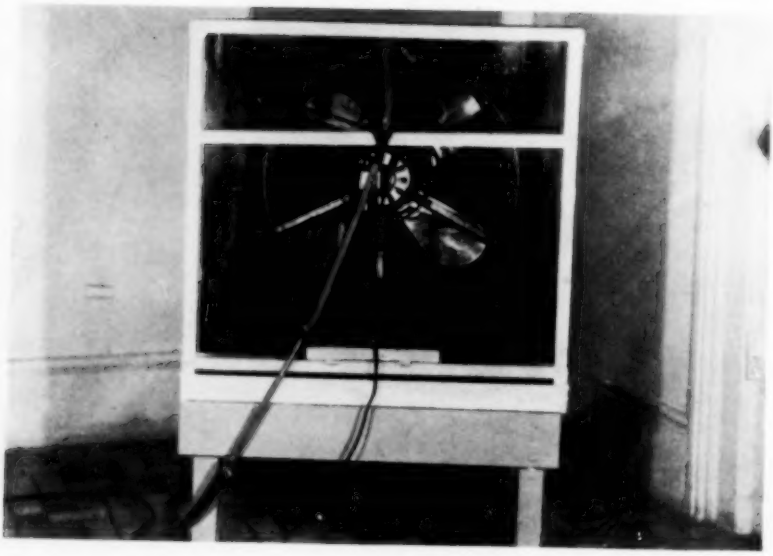
1. Mercury thermostat



2. Hair hygrostat



1. Front



2. Rear

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spreading blocks (Fig. 33, *2*). The two inner layers are 18 mesh and the outer layer 40 mesh. The evaporation surface is constructed in a semicircular form having a 12-inch radius. The ends are extended beyond the semicricle 4 inches (the distance between the pivot of the fan and the back of the tray), thus ensuring an equal distance from the fan to the screen throughout the oscillating range. The altitude of the surface is 25 inches. A galvanized iron tray (Fig. 33, IV), 24 inches square, provided with a drain (Fig. 33, *7*) to take off excess water, extends outside the evaporation surface and furnishes the base for the entire unit. To prevent the fan from coming in contact with water and the resulting trouble arising from possible short circuits, it is supported on a stand (Fig. 33, *5*). A solid galvanized-iron cover (Fig. 33, *3*) completely closes the top of the evaporation surface to prevent rising air currents from escaping over the top of the screen rather than passing through it.

Delivery of water through the nozzle is adjusted by supplying sufficient pressure to spray water to the outer screen only. One or two later adjustments, when the system has been in operation for a short time, will reduce the quantity of water delivered to the minimum necessary to meet the moisture requirements. The simplicity, low operating cost, and elasticity of this apparatus combine to make it an efficient piece of equipment and one that is readily altered to meet various individual demands.

PRESIDENT FRANKLIN SHERMAN: The next paper is by W. A. Baker and K. D. Arbuthnot.

THE APPLICATION OF ARTIFICIALLY DELAYING *MICROGASTER TIBIALIS* NEES DEVELOPMENT TO EMERGENCE AND LIBERATION

By W. A. BAKER and K. D. ARBUTHNOT, *U. S. Bureau of Entomology*

(Withdrawn for publication elsewhere)

PRESIDENT FRANKLIN SHERMAN: We will now listen to a paper by H. Glasgow.

A COMPARISON OF MERCURY COMPOUNDS IN ROOT MAGGOT CONTROL

By H. GLASGOW, *Geneva, N. Y.*

(Paper not received)

PRESIDENT FRANKLIN SHERMAN: We will now listen to a paper by C. L. Fluke, Jr., and K. Koch.

GRUB INFESTATION AS A POSSIBLE INDICATION OF CROP SELECTION BY JUNE BEETLES FOR EGG LAYING[1]

By C. L. FLUKE, JR., KARL KOCH, and L. F. GRABER, *University of Wisconsin*

ABSTRACT

Population studies of the white grub show that there are fewer grubs in certain legumes, indicating that adult beetles are plant selective in egg laying habits.

The productivity of the permanent blue grass pastures of southern Wisconsin has been greatly decreased during the past few years by the inroads of white grubs (*Phyllophaga* spp.) The value of sweet clover (Melilotus) as an aid to improve permanent pastures has been indicated by Graber[2] as well as methods of its establishment in sods without destruction of the grasses by plowing. That the presence of sweet clover in blue grass pastures might lessen the grub population in such pastures seemed possible.

Forbes[3] has shown that June beetles exhibit a decided preference for certain crops in which to lay their eggs. He found their first choice to be blue grass, followed in order by wheat, oats, clover, (presumably *Trifolium* spp.) corn and meadow. If the beetles preferred certain types of crops, it seemed very probable that they would choose between different kinds of legumes and that such selectivity in their egg laying habits could be ascertained by a determination of the number of grubs found in the soil under the different legumes.

In order to make such determinations, it was necessary to secure legumes growing in blue grass and in close proximity to each other so that in case the beetles exercised selective laying habits a choice of the different legumes could be made. The four acres of an old blue grass pasture used for this purpose was ideally located and consisted of a uniform sod of blue grass in which alfalfa, white clover, red clover, alsike and common white clover were established in 1929. The plot was fenced and was part of a large permanent blue grass pasture which had been slightly injured by grubs in 1927 and was heavily infested in 1929 and 1930.

[1]Published with permission of the Director of the Wisconsin Agricultural Experiment Station.

[2]Graber, L. F. 1927. Improvement of permanent blue grass pastures with sweet clover. Jour. Amer. Soc. Agron. 19: 994–1006. Illus.

———— 1928. Evidence and observations on establishing sweet clover in permanent blue grass pastures. Jour. Amer. Soc. Agron. 20: 1197–1205.

[3]Forbes, S. A. 1916. The influence of trees and crops on injury by white grubs. Univ. of Ill. Agr. Exp. Sta., Bull. 187.

The legumes were sown in the blue grass after proper fertilization and disking of the sod of the entire four acres early in the spring of 1929. The clovers were four to five inches high at the time the June beetles were flying in 1929 but the sweet clover and alfalfa were fully twice this height. All legumes were thickly established in the blue grass except in a few very small areas. Thus the female beetles had ample opportunities in May and June of 1929 to select the growth in which they preferred to oviposit. The relative position of the different legumes is given in the following diagram.

A DIAGRAM OF THE PLOT OF LEGUMES IN WHICH COUNTS OF WHITE GRUBS WERE TAKEN. IOWA CO., WIS., 1930

Sweet Clover and Blue Grass	Alfalfa and Blue Grass Alsike Clover and Blue Grass Red Clover and Blue Grass White Clover and Blue Grass
Blue Grass alone	
Sweet Clover and Blue Grass	

In July, 1930, population counts of the grubs were made in each plot, choosing representative areas equal to 1/20,000 of an acre, or approximately 2 square feet. Eleven such counts were taken in the sweet clover, 10 in the blue grass, and six each for alsike, white clover, red clover and alfalfa. It will be noticed that a narrow lane of blue grass divides the plot into two parts and it was in this lane that the grub counts for blue grass were obtained. The data are given in the following table.

A COMPARISON OF THE GRUB INFESTATION IN 5 DIFFERENT LEGUMES GROWING IN BLUE GRASS WITH THAT OF BLUE GRASS GROWING ALONE. IOWA CO., WIS. 1930

Growth	Average number of grubs per 1/20,000 of an acre	Rate per acre
Blue grass	11	220,000
Alfalfa	10	200,000
Alsike	8	160,000
White clover	8	160,000
Red clover	2	40,000
Sweet clover	1	20,000

It should be mentioned that the counts in the alfalfa, alsike clover and white clover may be somewhat higher than normal, because the growth in these three plots was quite thin in a few small areas. However, with the exception of white clover, which winterkilled early in 1930, all counts were taken only in areas having a thick stand. In the blue grass

pasture surrounding this plot the grub infestation was much higher, averaging about 440,000 per acre. The little lane of blue grass within the plot was apparently partly protected by the surrounding clovers.

From the results indicated in the table it is very evident that in this particular instance alfalfa growing in blue grass was almost as heavily infested as blue grass growing alone, while sweet clover and red clover on the other hand were apparently avoided by the beetles. Similar data gathered on three other plots of sweet clover established in old blue grass pastures tend to verify the assumption that June beetles avoid blue grass in which thick stands of sweet clover are growing during the egg laying period.

While these results with legumes and blue grass are only preliminary, they seem to indicate a decided crop selectivity by June beetles for egg deposition.

PRESIDENT FRANKLIN SHERMAN: The next paper is by A. W. Morrill.

NEW METHODS FOR LIBERATING *TRICHOGRAMMA MINUTUM* IN FIELD AND ORCHARD

By A. W. MORRILL, *Los Angeles, Calif.*

(Paper not received)

Mr. PHILIP GARMAN: I would like to inquire as to the approximate size of the capsules, and the number of parasites contained in each.

Mr. A. W. MORRILL: The type of capsule which is used handles about 200, if the so-called tops are used; whereas if the bottoms are used it will hold about 500. The larger sizes will hold several thousand. The veterinary capsules are used.

Mr. E. W. BERGER: I would like to know how you fasten the bottoms of the capsules together.

Mr. A. W. MORRILL: First you disassemble them; place the tops in one lot and the bottoms in another. Then you take two of the tops or two of the bottoms, and with the rounded ends in the same direction set one into the other, pressing them together with the thumb. They make a very tight fit and you can hardly pull them apart.

It is necessary to make a pinhole in one end of the capsule when it is closed in this way in order to relieve air pressure. The parasites live longer when there is an air hole of this sort. If the chamber is tight they die very soon after they are put in.

PRESIDENT FRANKLIN SHERMAN: J. L. King will now present his paper.

THE PRESENT STATUS OF THE ESTABLISHED PARASITES OF *POPILLIA JAPONICA* NEWMAN[1]

By J. L. KING, *Senior Entomologist,*[2] *U. S. Department of Agriculture*

ABSTRACT

Of the five established parasites of the Japanese beetle three are true parasites of *Popillia japonica* in Japan and two are parasites of allied Popillia occurring in Chosen (Korea). Considering these, *Tiphia popilliavora* gives much promise as an effective parasite of Popillia in the primary area of heavy beetle infestation, this no doubt being due to proper seasonal adjustment in relation to its host. The Korean *Tiphia vernalis* also seems to show proper seasonal adjustment, and the growth of the colonies in Pennsylvania and New Jersey indicates that the species may be of much economic value in the future.

With the Diptera in all three species there seem to be obstacles in the new or present environment which limit their increase. In *Centeter cinerea* there seems to be a direct response to climatic conditions which throws it out of alignment with its host. In *Prosena siberita* the difficulty seems to be with the host, that is, the climatic conditions are such that it has responded with practically a one-year cycle, which is not favorable to the parasite. Also, in the case of *Dexia ventralis* the lack of a two-year cycle of the host is not favorable and the new habitat does not supply the necessary secondary hosts which might carry the species over the periods when Popillia is in the pupal and adult stages.

The only solution for these ill adjustments, as seen by the writer, depends on the use of these parasites in the future when the host has extended its range into new environments, in zones climatically different from the present center of parasite introduction.

Popillia japonica presents three markedly different conditions in its life cycle in Japan as one progresses northward from Yokohama to Sapporo. This alone is sufficient evidence to indicate that as the species spreads northward in the United States, a two-year cycle will become more and more evident and will undoubtedly parallel the condition as described for Koiwai and Sapporo, Japan.

With *Centeter cinerea* the writer is of the opinion that a more northern climate is necessary to bring about a proper delay in its emergence so that it will appear with its host, and that only under these conditions can the parasite be of any economic value in the control of *P. japonica*.

In the case of *Prosena siberita* this parasite is likely to be of value in the biological control of *P. japonica* in regions where a two-year cycle occurs, thus supplying host material more timely and abundantly for the parasite.

Dexia ventralis has succeeded in producing two generations per year, apparently without alternate hosts and under adverse conditions. It is believed by the author that this species may be of considerable economic value in controlling *P. japonica* in regions where this host has an abundant supply of belated two-year larvae in the soil. Native Scarabaeidae if present in sufficient abundance, might also serve as alternate hosts.

[1]Contribution No. 88 of the Japanese Beetle Laboratory, U. S. Department of Agriculture, Moorestown, N. J.

[2]The writer wishes to acknowledge with appreciation the work of J. K. Holloway, R. W. Burrell, R. T. White, M. C. Swingle, and J. W. Balock, who have contributed materially to this work.

As the life cycle of the host has a direct bearing on the establishment of introduced parasites, it is necessary to give a brief comparative outline of the seasonal cycle of *Popillia japonica* as it occurs in New Jersey and Japan.

Variations in the Life Cycle of Popillia Japonica

In the Eastern United States. Within the densely infested areas of New Jersey and Pennsylvania *Popillia japonica* has for the most part a one-year cycle. The winter is passed mostly in the third larval instar. The adults appear in late June and reach their maximum abundance in July, and by the end of August the season may be said to be ended. First-instar larvae are abundant in the soil from July 15 to August 15. Second-instar larvae follow and are present from August 1 to September 15. The third-stage larvae do not appear in numbers before mid-August. Under somewhat exceptional conditions in low areas in moist soil, larvae may require two seasons before metamorphosis is completed. These retarded beetles have a two-year cycle, which in this region is exceptional, and the numbers of these individuals constitute only a minute fraction of the normal one-year group.

In Japan. In Japan in the latitude of Yokohama a one-year cycle is prevalent.[3] Here the adults reach their maximum numbers by June 20 and their season is entirely ended in late August. At Koiwai near Morioka, Japan (latitude 30.5° N.) the seasonal appearance of the adults corresponds quite closely to that described for New Jersey and Pennsylvania. In this latitude, however, about 25 to 30 per cent of the beetles undergo a two-year cycle. This condition seems to prevail in northern Honshu. In Hokkaido, adjoining Honshu on the north *P. japonica* has largely a two-year cycle with at least 75 per cent of the adult emergence in alternate years. During seasons of lesser emergence adults appear July 5 and the season is closed by the first week in August. During the seasons of beetle abundance July 5 again marks the start of emergence and mid-August closes the period of adult activity.

Under the conditions described for northern Honshu *P. japonica* larvae are present in the soil during any period of the year. In Hokkaido larvae are found in abundance throughout the summer during years of lesser beetle emergence, and during years of maximum emergence only a small fraction of the larval population are found in the soil during July.

[3]For details on the life cycle of *Popillia japonica* and its parasites see Clausen, C. P., King, J. L., and Terarishi Cho, "The Parasites of *Popillia japonica* in Japan and Chosen (Korea) and Their Introduction into the United States," U. S. D. A. Bul. 1429. 1927.

The Established Dipterous Parasites of Popillia japonica

During the course of parasite introduction seven species of dipterous parasites have been received at the Japanese Beetle Laboratory and six of these have been released in an effort to establish them. However, only three species have been recovered.

Centeter cinerea Aldrich

The tachinid, *Centeter cinerea*, is distributed irregularly on the higher elevations over the northern half of Honshu and generally over the island of Hokkaido.

Centeter cinerea is a parasite of adult *P. japonica* and is strictly specific in its host selection. The eggs of this parasite are deposited on the thorax of the host. The eggs hatch in 36 to 48 hours and the young larvae penetrate the thoracic wall of the host and develop as internal parasites. Development from egg to puparium requires 10 to 12 days. The winter is passed in the puparia in the soil. There is but a single generation per year.

Centeter cinerea was successfully established in New Jersey in 1923 and by 1927 through natural spread it occurred over an area of 75 square miles. The present territory covered by this species is 1,550 square miles, having a nucleus of eight colony centers, five in Pennsylvania and three in New Jersey. There are two colony centers in Connecticut.

In Japan *C. cinerea* occurs in two regions where its host reacts quite differently in yearly cycle owing to climatic differences as has been described for northern Honshu and Hokkaido. At Koiwai in northern Honshu, although *P. japonica* undergoes in part a two-year cycle, the number of beetles present in the field each year is quite constant. Here *C. cinerea* effects a parasitism of 42.1 per cent of the female beetles and 1.4 of the males. Parasitism commences on the first beetles of the season and extends well on through the period of host activity.

At Sapporo, where *P. japonica* appears abundantly during alternate years, parasitism by *C. cinerea* is high during years of lesser host abundance. At such times 80 per cent or more of the female beetles are parasitized and this is maintained through the greater period of beetle abundance. At the same time parasitism of male beetles is high, starting at 80 per cent and dropping to 50 per cent during mid-season, then gradually declining during late July and early August.

In the same locality during years of host abundance parasitism by *C. cinerea* is low, averaging 19.5 per cent for the female host and 1.1 per cent for the male host. This parasitism extends uniformly through-

out the beetle season, showing that *C. cinerea* is properly adjusted in its seasonal appearance with regard to its host. The low parasitism in years of host abundance is explained by the actual lack of host material and ineffective multiple parasitism during the preceding year.

SEASONAL RELATIONSHIP OF CENTETER AND POPILLIA IN NEW JERSEY AND PENNSYLVANIA. It is noted in the foregoing description that at both Koiwai and Sapporo, Japan, *Centeter cinerea* is an effective parasite and that it is present throughout the greater part of the beetle season, which indicates a proper seasonal correlation of parasite and

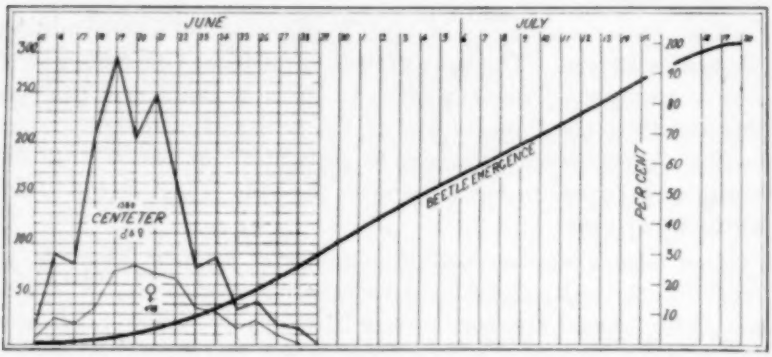


FIG 34.—Diagram showing lack of synchronization in the emergence of *Centeter cinerea* and *Popillia japonica*. This condition prevails in the region of Philadelphia.

host. At Moorestown, New Jersey, where most local observations are conducted, it has been found over a period of six years that only the first beetles of the season are parasitized by Centeter. This parasitism may reach 10 per cent within very limited and local areas, but it drops rapidly as the season advances and the beetles become more abundant. Experimental rearing of *C. cinerea* under outdoor conditions has confirmed field observations, indicating that the parasite emerges two to three weeks or more in advance of the peak of host emergence, Fig. 34.

The early emergence of *C. cinerea* seems to be explained in part by the fact that the mean monthly temperature for the first six months of the year in the Philadelphia region averages from 7° to 10° F. warmer than the corresponding temperatures of Koiwai and Sapporo, Japan, the two localities where *C. cinerea* is found abundantly. The chief differences in the last six months of the year are that in the Philadelphia region the maximum temperatures occur in July with a gradual decline to winter temperatures, whereas at Koiwai and Sapporo the maximum

summer temperatures are attained in August and the decline to winter temperature is rapid. These differences give the Philadelphia region a growing season five weeks longer than in the Japanese localities mentioned, and it is undoubtedly this additional warmth which stimulates the early emergence of *C. cinerea* in its new habitat. This condition would then indicate that *C. cinerea* will possibly be of value in more northern habitats similar in yearly temperatures to those of northern Honshu on the higher elevations and of Hokkaido.

Prosena siberita Fabricius

Prosena siberita has a wide distribution, being found throughout continental Asia, Europe, and the Oriental region, where it has been recorded from Java. In Japan the species is abundant in northern Honshu and on the island of Hokkaido.

In the areas where *P. siberita* is now established the adults are on the wing during July and a few in August. Parasitism is effected by the deposition of minute planidia-like larvae on the soil. These larvae search out the larvae of *P. japonica* and penetrate the body wall. The larvae then live as internal parasites attached to the tracheal tubes in the anterior portion of the body of the host. The winter is passed as a partly grown second-instar larva within the host. There is a single generation per year.

Prosena siberita was first colonized at Moorestown, New Jersey, in 1923 and from then to 1926 some 6,315 males and females were liberated in this district. The first recovery of the species was made in 1927. Subsequent recoveries in the Moorestown district indicate that the species is successfully established, but that the colony is yet small and in the first stages of establishment. Extensive liberations were made in Pennsylvania in 1930.

Seasonal Relationship of Prosena and Popillia. In Japan *P. siberita* is most abundant in the regions where *P. japonica* has in part a two-year cycle. This condition of the host is particularly favorable for *P. siberita*, as it insures the parasite a constant supply of host material at a time when larvae would otherwise be scarce if the host's cycle were completed in a year. There are other conditions in Japan which are equally favorable, namely, that *P. siberita* has other hosts which undoubtedly are in the larval state during the time the young parasite larvae are searching for their hosts.

In New Jersey. In the new habitat in New Jersey and Pennsylvania the dominance of a one-year cycle for *P. japonica* places *P. siberita*

under somewhat unfavorable conditions as compared to those just described for Japan. First, the period of adult activity with *P. siberita* has moved forward slightly with the peak of female emergence about July 20. As the females of this species have an average gestation period of a week to ten days before larvae are produced, the peak of larvaposition occurs near the first of July. When these dates are compared with the average seasonal appearance of the larval stages of the host, it is found that first-instar host larvae are abundant at the time

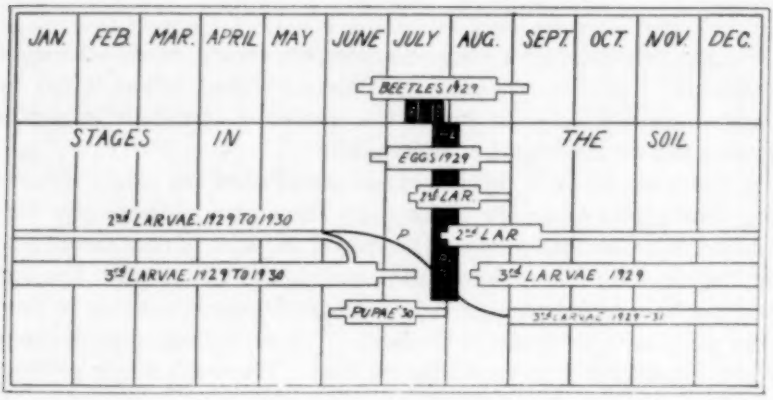


FIG. 35.—Diagram showing the seasonal relationship of *Prosena siberita* with the various stages of *Popillia japonica* in the region of Philadelphia, P. indicates the thread of 2-year cycle larvae of *Popillia;* PL, indicates the period P. *siberita* larvae are actively searching for their hosts.

the parasites are present, but this stage is not readily parasitized by *P. siberita*. Second-instar larvae, which are readily parasitized, are appearing but are not numerous; and third-instar larvae, which also are parasitized, are exceedingly scarce, being represented only by the trace of two-year cycle larvae which were mentioned in the paragraph on the host, Fig. 35. There are no known native scarabaeids yet recorded as hosts of *P. siberita*.

The foregoing indicates that in the present new environment of *P. siberita* conditions are not entirely favorable for the rapid increase of the species, and this may explain in part the slow growth of the present colony. It would seem that *P. siberita* is better adapted to a two-year cycle of *P. japonica* and it may prove more effective as a parasite of that species when *P. japonica* becomes established in northern areas where a two-year cycle will undoubtedly be developed.

Dexia ventralis Aldrich

Dexia ventralis was found by the writer at Suigen, Chosen (Korea), May 25, 1922. This dexiid is the most abundant species in Chosen and is also found throughout the plains area of Manchuria.

Dexia ventralis deposits living larvae on the soil, and these seek their hosts in the manner described for *P. siberita*. In Chosen the species has in part three generations per year when certain overwintering hosts become parasitized, but when Popillia is the overwintering host two generations occur. The species winters as a partly developed second-instar larva within the host. *D. ventralis* is not a true parasite of *P. japonica* but it attacks allied species of Popillia and other Korean scarabaeids.

Experimental rearings of *D. ventralis* indicate that any stage of the larva of *P. japonica* can be successfully parasitized by it but that a marked preference for the later stages is shown, in the selection of advanced second-instar or more often third-instar host larvae.

Dexia ventralis is successfully established in one colony near Haddonfield, New Jersey, where liberations were made by the writer in 1926. Recoveries at this colony center have been made each subsequent year; however, the species does not seem to increase rapidly in numbers and is not yet of economic importance in the control of *P. japonica*. Extensive liberations were made in Pennsylvania during the summer of 1930.

Seasonal Relationship of Dexia and Popillia in New Jersey. In New Jersey life-history observations indicate that *D. ventralis* has but two generations per year, and no alternate hosts have been recorded from the field. The first brood of adults is on the wing between June 11 and June 29, and the second brood between July 30 and August 26. These periods indicate the time of larvaposition, or the periods during which the first-stage larvae should be seeking their hosts. Comparing these periods with the stages of the host, some idea may be gained as to the success of the parasite in the region where it is now established. The first brood, occurring in the latter half of June, finds only a small number of host larvae which have not become prepupae or pupae and the trace of two-year-cycle Popillia larvae which occur in moist soils. No alternate hosts are yet known in this region, so the first generation of *D. ventralis* meets adverse conditions. The second brood finds more host material in the form of second-instar hosts, early current third-stage larvae, and the trace of two-year cycle larvae also in the third stage, Fig. 36.

The foregoing condition may explain in part why the species does not increase more rapidly in numbers, in that the gain made by the second generation is lost the following year in the summer brood through lack of hosts. The condition also indicates that *Dexia ventralis* should be more successful in regions where *P. japonica* would normally undergo a two-year cycle. In the new habitat where the species is now established the presence of alternate hosts in the soil during the activities of the first generation would be of benefit to the species, but so far these are not known to occur.

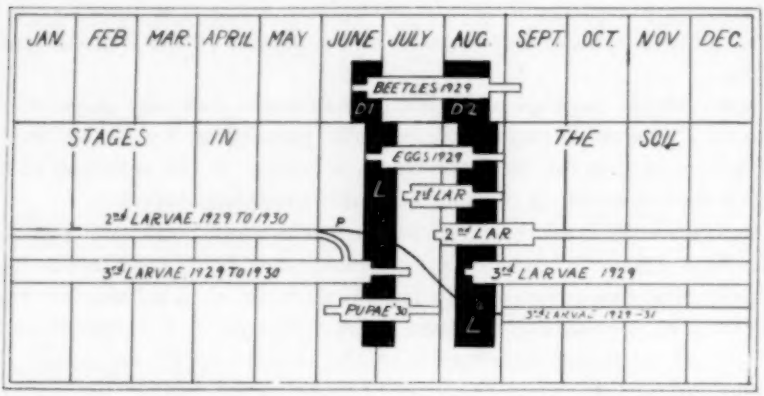


FIG. 36.—Diagram showing seasonal relationship of *Dexia ventralis* with the various stages of *Popillia japonica* in the region of Philadelphia. D1, first brood of *D. ventralis* adults; D2, second brood of *D. ventralis* adults; L, the periods *D. ventralis* larvae are actively searching for their hosts.

THE HYMENOPTEROUS PARASITES OF POPILLIA.

The family Scoliidae has been extensively studied with regard to possible parasites to be used in the control of *P. japonica*, and eight species have been received in sufficient numbers for successful rearing or releasement. These consist of six species of Tiphia, one species of Campsomeris, and one species of Scolia. Up to the present time the only ones that have been established are two of the species of Tiphia.

TIPHIA POPILLIAVORA ROHWER

Tiphia popilliavora was found by Clausen at Koiwai, Japan, in 1920. The species is known to be abundant only in the place of discovery; however, it has a wide distribution, as indicated from specimens taken in central Japan, Chosen, and China.

Tiphia popilliavora is a specific parasite of *P. japonica*. The adult *T. popilliavora* are on the wing during the month of August and the first week in September. Parasitism by Tiphia is effected by the direct placement of a single egg on the host larvae which are sought by female Tiphia. The Tiphia larvae are external parasites on the host. There is but one generation per year.

Tiphia popilliavora was colonized near Riverton, New Jersey, between 1921 and 1923. The first recoveries were made in 1926 and 1927 in three separate areas. These areas have since increased in size and are now united in one colony covering an area of approximately 4 square miles. Within this area the species has become very abundant. Since 1927 artificial distribution has been conducted to augment the spread of this beneficial species. In 1929 seven men, collecting in the central colony over a period of 17 days, took an average of 594 females of *T. popilliavora* per day and a total of 10,000 during the period.

Units of 100 female *T. popilliavora*, when placed where Popillia larvae are abundant, seem quite sufficient for the successful establishment of the species. The colonies of this species total 145. Two of these are on Long Island, New York; one at New Haven, Connecticut; and one at Harrisburg, Pennsylvania; the remaining colonies are locally distributed within the beetle-infested areas of New Jersey and Pennsylvania. *T. popilliavora* gives much promise of being an effective parasite of *P. japonica*.

Seasonal Relationship of Tiphia Popilliavora and Popillia Japonica in New Jersey and Pennsylvania. The period of emergence of *Tiphia popilliavora* in New Jersey and Pennsylvania is fairly well correlated with the proper stages of its host. This period of activity during August places the species in the field when normally an abundance of well developed second-instar host larvae are present, and this stage serves as suitable host material for the parasite. Third-stage Popillia larvae, which are also readily parasitized, are found in considerable abundance at this time, Fig. 37.

The specific habits of *T. popilliavora* and its proper seasonal adjustment, together with its present success, indicate that the species will be of much value in the biological control of *P. japonica*.

Tiphia vernalis Rohwer

Tiphia vernalis was found by the writer at Suigen, Chosen (Korea), in May, 1922. This Tiphia is common throughout Chosen. It is also recorded from Eastern China and Japan; however, it is not common in this latter country.

The habits of *T. vernalis* are generally similar to those of *T. popilliavora* except for the period of adult activity, which is between May 5 and June 15. The species has but one generation per year. *T. vernalis* was found in Chosen to be parasitic on *Popillia castanoptera* Hope and *P. atrocoe rulea* Bates. The writer successfully reared the species on larvae of *P. japonica* which he took to Chosen from Japan in 1922. It was found to accept and develop on *P. japonica* as well as on the local species of Popillia.

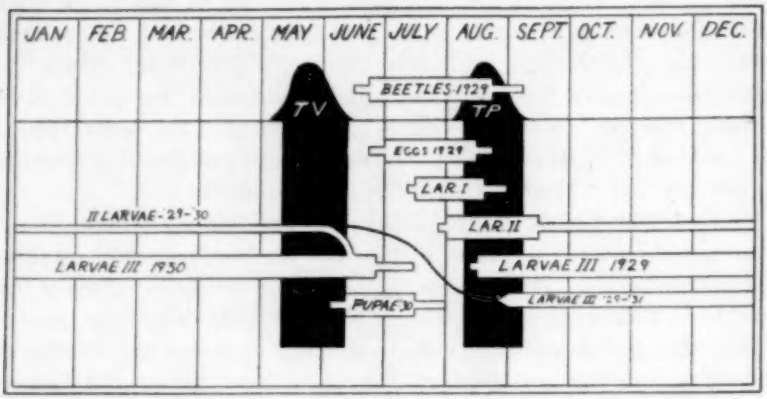


FIG. 37.—Diagram showing seasonal relationship of *Tiphia vernalis* TV, and *Tiphia popilliavora* TP, with the various stages of *Popillia japonica* within the region of Philadelphia.

The species has been successfully introduced through shipments of field-collected adults from Chosen. Up to the present time 17 colonies have been placed in the field, between 1926 and 1930, and 4 of these have recovery records. One of these in particular, at Philmont, Pennsylvania, has shown much increase, giving every indication that the species is becoming well established and will be an important one in the biological control of *P. japonica*.

SEASONAL RELATIONSHIP OF TIPHIA VERNALIS AND POPILLIA. *Tiphia vernalis* seems to be very well placed as concerns its period of activity, for at the time the females are searching for their hosts an abundance of third-instar larvae are available, Fig. 37.

PRESIDENT FRANKLIN SHERMAN: We will now listen to a paper by J. A. Hyslop.

A SIMPLE FILING SYSTEM FOR A STATE INSECT PEST SURVEY

By J. A. HYSLOP, *Bureau of Entomology*

The desirability of having in every economic entomological institution a permanent record of the distribution and periodical abundance of the insects infesting the territory which this institution serves is so evident that arguments are quite unnecessary.

Granting the desirability, why are so few such records maintained? Principally because the entomologists realize the magnitude of such an undertaking and feel that they have neither the finances nor the personnel to undertake so monumental a task. This is a misconception. The scope of the work is enormous, but this work grows of its own inertia once it is properly launched. To launch the project does not require extra personnel and but little equipment and supplies.

I believe that any entomologist can start a Survey for his State with his present equipment and personnel and I do not believe that any entomologist is so busy that he can afford to neglect this fundamental phase of his work.

The necessary equipment to start a State Survey would be about three six-drawer sections of card-filing cabinet (18 drawers), about 500 guide cards and 5,000 note cards, costing less than $200.00.

I feel that the second impediment in way of starting a State Survey is the lack of a definite system to follow.

I am, therefore, describing the filing system used by the Federal Insect Pest Survey, which has been adopted after ten years' practical experience. I believe this system could be easily adapted to a State Survey.

The first considerations in any filing system are uniformity and standardization. Decide upon a convenient sized record card, then reduce or enlarge all maps, tables and report forms to this one size. We decided upon a 5″ x 8″ standard. When larger maps or graphs were found to be necessary, the size chosen was a multiple of the standard size that could be conveniently folded and filed with the other notes. We can not too strongly stress the importance of having all the information in one system.

The next consideration in filing is to make the system so simple that clerical help can put notes away without a knowledge of insect taxonomy.

The files maintained by the Insect Pest Survey are arranged strictly alphabetically by genera, regardless of higher ordinal classification.

Under each genus the species are arranged alphabetically and under each species the notes are filed alphabetically by states and chronologically under each state. In a state survey, the notes could be arranged chronologically under each county. We use standard guides cut to fifths. The genus and species guides, in other words the insect-name guides, are buff; the genus in the second position and the species in the fourth position. The third position, that is, the middle position, is reserved for families and orders. These guides are salmon in color and behind them are filed notes in which the insect involved has only been determined to the higher ordinal rank; they do not indicate a separation of the genera into families, orders, etc. Locality guides are blue; those for States in the Union are placed in the fifth position and those for foreign countries in the first position back of the domestic notes. In State work, these blue guides could be used for counties.

As an insect is often referred to under either two or more generic or specific names, we attempt to file notes under the most approved name and underline the obsolete designation with red, leaving its guide in the files, but putting a cross-reference on the guide card. For example, a note on *Pontia rapae* is to be filed. The species guide card *rapae* is marked red and below is written "*See Pieris.*" The file clerk coming to this guide, marked red, realizes at once that nothing is to be filed behind this guide and turns to the cross-reference to file the note in its correct place.

As the files become more extensive we find it convenient to summarize certain of the data on summary cards.

The first of these is a map of the world upon which is marked the world distribution, the second is a United States map upon which is marked the distribution within our own borders. Following these distribution maps is a summary list of the food plants of the given insect. Following this is a list of the parasites and predators that are known to attack this insect and if the insect be a parasite or predator, there is a list of its host insects and also a list of parasites and which, of its various hosts, are hyperparasites.

We also maintain a file of host plants similarly alphabetically arranged. Here is to be found a list of the insects known to infest any given plant. On all of these summary cards we allow space for a brief citation of the authority and the place that the observation was made.

A simple geographical distribution map is of decided interest. However, we have found a much more valuable type of map to be one upon which is recorded the frequency or intensity of the damage by a given insect. These are designated as intensity maps. For our purpose the

county is considered as a unit. On this map a dot is placed in each county, each year that an insect is reported as doing damage in that county. After a series of years, one can detect at a glance by the density of the dots the sections of the state and the United States where a given insect is usually troublesome.

Following this summarized general information are the state notes, separated by alphabetically arranged state guides. Immediately behind the state guide is a map of the state showing the county lines upon which is indicated the localities from which the insect has been reported in each county. It is from these state maps that we compile the United States map and world maps. In a state survey when the mass of information warrants the subdivision, county maps could be used showing townships.

Now we have a simple filing system. Next, start immediately to make cards for all current observations.

As time permits (and here is excellent work for advanced students) review the local literature on the insects of the state and make cards from these records. Transfer to standard cards old correspondence records and note files in the institution.

Next, the general literature on economic entomology should be reviewed for state records; then the college insect collection examined; finally, the specialists on groups should be consulted for additions and corrections to the lists so compiled. This is the work of several years but each record filed never has to be looked up again and in the end you will have a list of the insect pests of the state that will be a very valuable contribution to the literature of economic entomology.

A system of voluntary reporting by workers throughout the state will soon develop from this start, but we can not treat this organization phase of survey work here.

A start must be made for every big job and every entomologist with the courage of his convictions can and should start a State Insect Pest Survey.

PRESIDENT FRANKLIN SHERMAN: The next paper is by M. D. Leonard and A. S. Mills.

A PRELIMINARY REPORT ON THE LIMA BEAN POD-BORER AND OTHER LEGUME POD-BORERS IN PORTO RICO

By M. D. LEONARD, *Chief Entomologist, Insular Experiment Station, Río Piedras, Porto Rico* and A. S. MILLS, *Junior Plant Quarantine Inspector, U. S. D. A., San Juan, Porto Rico*

ABSTRACT

Preliminary observations on the distribution, life-history, economic importance, and food-plants of the lima bean pod-borer, ***Maruca testulalis*** Geyer. While searching for the food-plants of the lima bean pod-borer, the Pyralids *Etiella zinckenella* Treit. and *Fundella cistipennis* Dyar, and the Gelechiid, *Brachyacma palpigera* Wlsm. have been reared from the pods of the legumes. Preliminary notes are also given on these species and their parasites, as well as on several other species of lesser importance.

Effective July 1, 1925, U. S. Plant Quarantine No. 58 was promulgated prohibiting the shipment of green string and lima beans from Porto Rico to the mainland of the United States on account of the lima bean pod-borer, *Maruca testulalis* Geyer. In 1929 this quarantine was modified so as to permit shipment of fresh beans to the port of New York between November 1 and March 31 under inspection. During the season of 1929–30, a total of 908 bushel hampers of string beans and 71 of lima beans were shipped under this arrangement but at least 204 hampers of string beans and 14 hampers of lima beans were rejected by federal inspectors at the dock at San Juan. Although the growers attempted to cull out infested beans before packing it can be seen that they were not entirely successful in doing so. After having one or two lots rejected several of the growers became discouraged and did not offer any more beans for shipment during the remainder of the season.

Fresh beans from Porto Rico would normally bring an excellent price on the New York market during the months of November to March but due to the quarantine made necessary by the lima bean pod-borer and consequent rejections of shipments, it is expected that a much smaller quantity of fresh beans will be grown and offered for shipment during the coming season. In an effort to improve this situation a study of the lima bean pod-borer in Porto Rico has been started with a view to working out control measures in the field and if possible supplementing those with some treatment before shipment so that the borers would be killed and the beans could be sent to the States.

Since comparatively few beans are grown during the summer and early fall in Porto Rico, we have as yet not had the opportunity to work out the details necessary for a more thorough understanding of this pest. Some observations have, however, been made on the lima

bean pod-borer and several other species of lepidopterous pod-borers found in an attempt to determine the food-plants of Maruca and it seems advisable to put them on record pending a more detailed report later on.

Maruca testulalis GEYER

DISTRIBUTION. This species seems to be generally distributed thruout the subtropical and tropical zones of both the New and Old Worlds. In Porto Rico where it is apparently widely distributed we have definite records from the following localities: Río Piedras, San Juan, Santurce, Bayamón, Manatí, Cidra, Isabela, Mayagüez, San Germán, Guánica, Coamo Springs, and Aguirre. At several of the above localities the moths have been taken commonly at light. The insect is apparently more abundant during the fall and winter months at which time more beans are grown.

FOOD PLANTS. This species has been reported as infesting green gram, *Phaseolus mungo* in Java; on green gram, red gram, and *Dolichos lab-lab*, (Fletcher, Some South Indian Insects, p. 440, 1914) and on cowpeas (Pillai, Travancore Dept. Agr. 1921) in India; rice in Burma (McKerral, Rept. Dept. Agr. Burma 1923–24:14–15, 1924), cowpeas in Sumatra (De Bussy, Meded. Deli. Proefstat. Medan 9 (4) : 112–121, 1915 & Dietz, 8: 273, 1914) and green gram (Dietz, 1914); beans in Samoa (Hopkins, Bul. Ent. Res. 18 (1) :29 1927) and in Cuba (Bruner et al., Rev. Agr. Com. y Trab. Cuba 11: 31–35 1930). In Porto Rico we have found it only in string beans and lima beans. It had formerly been recorded, however, on sword beans and pigeon peas but there is only one record for each of these two plants.

ECONOMIC IMPORTANCE. The lima bean pod-borer was reported by Dietz in 1914 as widespread, and consequently we assume fairly injurious to green gram on the east coast of Sumatra but he states that the damage done to cowpeas is often greater than that to green gram. Fletcher (1914) states that it is a minor pest of pulses thruout southern India. Other writers indicate that it is a pest of relatively minor importance on its food plants other than beans. Its greatest commercial damage is apparently done to lima beans. Hopkins (1927) stated that beans in his garden in Western Samoa had been extensively damaged. A considerable quantity of lima beans are now grown in Cuba for shipment to New York during the winter months and this bean pod-borer is undoubtedly a pest of first class importance on that island.

In Porto Rico the infestation of Maruca apparently varies considerably but is higher during the winter months. The following figures based

on examinations made in the field or in picked beans give an indication of the amount of infestation: Río Piedras, Aug, 16 1930, string beans, 5%; Cidra, Sept. 12, 1930, 20%; Isabela, Oct. 31, 1930, string beans, 18%; Mayagüez, Oct. 31, 1930, string beans, 5%. At Río Piedras on Dec. 5 1930, 5% and 9% of the blossoms of lima beans were found infested on two farms. U. S. Plant Quarantine inspectors C. P. Trotter and R. W. Nicaise recorded 85 hampers of string beans from Manatí as heavily infested on Nov. 18, 1929. Based on field and dock inspections it would seem that string beans are somewhat more susceptible to infestation than lima beans.

LIFE-HISTORY. Little has been done in determining the life-history of this bean pod-borer. The only account we have been able to find is a short one by Dietz in 1914. He states that on the east coast of Sumatra the eggs are laid on the flower-buds of cowpeas and green gram, the caterpillar boring into the bud and consuming it from within outward; it later bores into the pods and eats the seed; pupation takes place in the ground but often in the pods, the pupal period being 9–10 days; the total life-cycle takes 5–6 weeks; the larvae sometimes bore into the stems in the later stages in which case they pupate in the ground. Fletcher (1914) states that the pupal period is about a week in Southern India.

We have as yet been unable to complete any life-history observations in Porto Rico except to determine the pupal period as lasting 6 to 8 days. Most of the pupae from which we have reared adults have formed on the lids of the tin salve boxes in which the infested pods were placed, but occasionally they were formed within the pods; none pupated within sand placed in the boxes. We have not as yet succeeded in finding eggs. Larvae as small as 2 mm. in length have been observed feeding within the blossoms and larvae as small as 7 mm. have been found in the pods.

PARASITES. On January, 30, 1930, Mr. C. P. Trotter found a dipterous larva in a dead Maruca larva which was determined in Washington as Sarcophaga sp. Mr. S. C. Bruner has recently written us that the most important parasite in Cuba is *Microbracon thurberiphagae* Mues., but that the larva was also occasionally attacked by Apanteles n. sp., and somewhat more commonly by the fly *Argyrophyla albincisa* Wied.

CONTROL. Fletcher (1914) has suggested the collection and destruction of infested pods in India. Cotton (Jour. Dep. Agr. P. R. 2:279, 1918) made the same suggestion for Porto Rico and further recommended that spraying with arsenate of lead would kill a great many of the larvae before they could eat their way into the pods. Bruner et al. (1930) have recently carried on a series of experiments in Cuba in which

they subjected infested lima bean pods to heat and cold, and to hydrocyanic acid gas and carbon bisulphide, the two latter under partial vacuum. The carbon bisulphide was the only one which produced sufficiently good results to give promise of being satisfactory for use on a commercial scale. It at once destroyed a high percentage of the larvae and those remaining alive died shortly afterwards. Apparently the pupae were similarly affected.

Facilities are not available at the present time for fumigating under partial vacuum in Porto Rico.

Etiella zinckenella TREITSCHE

In the course of our studies on *Maruca testulalis* we have reared a number of other moths from the pods of lima and string beans, pigeon peas, and of one or two other legumes. Specimens sent to the U. S. Bureau of Entomology were determined for us as *Etiella zinckenella* Treit. This species has not heretofore been well-known in Porto Rico, being recorded without definite locality in Wolcott's List (Jour. Dept. Agr. P. R. 7 (1):200, 1923) only on the authority of Gundlach and Moeschler.

DISTRIBUTION. This almost cosmopolitan species was originally described from Sicily in 1832 (Treitsche, Schmet. Eur. IX, 1, p. 201) and has been recorded in literature also from France (Milliere, Assn. Soc. Linn; Lyon 8:231, 1861 (?)), Hungary (Kadocsa, Folia Ent. Hungar. 1 (2):41–43, 1924), Russia (Kolesnikov, Jour. Agr. & For. Petrograd ccli (6):191–234, 1916); (Sakarov Trans. Saratov Agr. Exp. Sta., 2 pp., 1923); Egypt (Forbes, Sultanic Agr. Soc. Tech. Sec. Bul. 9, 1–22, 1921), the Dutch East Indies (Van Hall, Meded. Inst. Plantziekten 58; 1923; 64, 1924; 67, 1925; 70, 1926) and Ceylon (Henry, Trop. Agr., 47 (2):94–100; Jepson, Ceylon Admin. Repts. Dept. Agr. 1923, pp. D19–D21, 1924). Zeller referred to this species specimens examined by him from West Africa, Madagascar, and from Colombia in South America. Hulst recorded it from Colorado and California under the specific name *villosa* and Dyar added Arizona. Hyslop stated in 1912 that the U. S. National Museum collection contained specimens of typical *zinckenella* from New Hampshire, Rhode Island, Florida, Saskatchewan, Texas, Oklahoma, and Colorado.

This species seems to be known in the West Indies only from Cuba and Porto Rico. Mr. Bruner writes us that he has reared it from lima beans in Cuba. In Porto Rico it is widely distributed at least in the lower parts of the island and fairly abundant. Specimens have been

collected in a number of localities on or near the coast as well as on Vieques Island.

FOOD PLANTS. This pod-borer has been recorded as infesting a considerable variety of legumes, including various wild and cultivated legumes and Acacia in Russia, soybeans in the Dutch East Indies, *Tephrosia candida* in Ceylon, green peas, lupine, and *Robinia pseudacacia* in Hungary, and *Colutea arborescens* in France. In Porto Rico we have found it in lima beans, pigeon peas, crotalaria, and cowpeas. It is an important pest of lima beans but it is even more common in pigeon peas.

LIFE HISTORY. Chittenden (U. S. Bur. Ent. Bul. 82 pt. iii, 1909) described the larva and stated that specimens placed in a rearing jar with sand burrowed down to depth of about an inch where they spun a light web. Hyslop (U. S. Bur. Ent. Bul. 95 pt. vi, 1912) has studied it under the name of *E. schisticolor* in Washington and a very detailed investigation of the species has been made by Flanders (Calif. Dept. Agr. Mo. Bul. 19 (6):409–421, 1930) in California, also published as *schisticolor*.

We have as yet only made observations on the length of the pupal period in Porto Rico. Nine moths emerging early in June spent 9 to 14 days in the pupal stage and 10 moths emerging during August spent 9 to 12 days. Mature larvae placed upon earth or sand at once burrowed beneath the surface where they formed tough, silken cocoons. The larvae apparently enter the pods while very young and at once begin to feed upon the seeds.

PARASITES. Although a number of parasites have been recorded by Hyslop and Flanders from *E. schisticolor*, the only record we have been able to find for *E. zinckenella* seems to be that of a single specimen of an undetermined ichneumon bred in 1908 by Chittenden.

We have reared three specimens of parasites from the larvae which were submitted to Mr. Gahan for determination. One he believed to be *Heterospilus etiellae* Rohwer, another was a male Eurytoma resembling *E. insularis* Ashmead, while the third was a female Eurytoma which may be the female of the foregoing specimen. Mr. Gahan states that it will be necessary to have more material to substantiate these determinations.

CONTROL. Careful experiments have been conducted by Hyslop (1912) in Washington and by Flanders (1930) in California in its control as a lima bean pest. Flanders' experiments indicate that proper timing of the harvesting of the crop, irrigation, and deep plowing seem to offer the best means of decreasing injury under California conditions. In Porto Rico the control will undoubtedly have to go hand in hand with that of Maruca.

Fundella cistipennis DYAR

DISTRIBUTION AND FOOD PLANTS. So far as is known this species is confined to the West Indies. It was originally described by Dyar in 1913 (Proc. U. S. N. M. 44:323) as *Ballovia cistipennis* from Barbados on cowpeas. It was next mentioned by Harland in 1917 as a hitherto unrecorded pest of cowpeas in St. Vincent. It was noticed attacking pods of pigeon peas and cowpeas in St. Vincent in 1921 and was again mentioned as attacking the pods of pigeon peas in 1923 (Repts. Dept. Agr. St. Vincent for 1921:24 and for 1923:29). Wilson (Virgin Ids. Agr. Exp. Sta. Bul. 4:5–6, 1923) records it as abundant in the pods of Canavalia spp. in St. Croix and also reared a few specimens from cowpeas there. It is represented in the U. S. N. M. also from Port-au-Prince, Haiti.

In Porto Rico this species was reared from larvae boring in the stalks and pods of cowpeas from Río Piedras several times in 1912 and 1914 by T. H. Jones. He also reared adults from the pods of *Cassia occidentalis* in 1914 and recorded it as attacking beans and sword beans in 1915. We have found lima beans moderately infested and cowpeas more so in May, 1930 at Río Piedras and pigeon peas moderately infested in July at the same place. Moths were collected at light by W. T. M. Forbes at Cataño and on Vieques Island in late April, 1930.

LIFE HISTORY. Harland (Rept. Agr. Dept. St. Vincent. 1916–17, p. 10, 1917) gave the first brief notes on the life-history of this pod-borer. He stated that in St. Vincent the eggs are laid usually at the top of the flower stalks or in the calyx of the young bud, hatching in 2 to 3 days, the larval stage lasting about 8 to 9 days, pupation taking place in the soil and the moth emerging about a week later. Wilson (1923) has worked out the immature stages and life-history in somewhat more detail in St. Croix. He states that the eggs are deposited any place along the seed pod and hatch in 5 to 8 days, the larval period lasts 14 to 25 days, pupation takes place in a tough cocoon covered with grass, and the adult emerges in 14 to 18 days. Wilson states that his life-history observations were made during August, February, and April and that the insect seems to undergo a dormant period during May, June, and July, the broods reaching their height in August, October, December, February, and April.

We have found the pupal period in Puerto Rico to last 8 to 12 days from rearings made during May, July, and August, 1930.

Wilson (1923) and Cotton (Jour. Dept. Agr. P. R. 2:292–293, 1918) recommend collection and destruction of infested pods.

Brachyacma palpigera WALSINGHAM

Examining dry pods of pigeon peas in a large planting near Río Piedras in June, 1930 we found that a high percentage contained small whitish larvae feeding upon the seeds. Specimens submitted to Mr. August Busck of the National Museum were determined as *Brachyacma palpigera* Walsm., with the statement that this is an equatorial species found in India, Ceylon, Africa, China, Central America, Brazil, and the West Indies. A single adult (recorded as *Lathontogenus palpigera* Walsm.) was reared by Bottimer (Jour. Agr. Res. 33 (9):812, 1926) at Kingsville, Texas in 1923 from the pods of *Vachellia farnesiana* (L.). In the West Indies Dr. W. T. M. Forbes has collected moths of this species on St. Thomas, March 11 to 19, and St. Croix, April 27 to May 5 (N. Y. Acad. Sci., Sci. Surv. P. R. 12 (1):123, 1930). It also occurs in Trinidad where Busck described as new a genus and species, *Lipatia crotolariella*, now considered a synonym of this species (Trinidad Dept. Agr. Bul. Vol. 9, No. 66:243–244, 1 fig. 1910).

In Porto Rico, Dr. Forbes collected adults at light at Coamo Springs, April 5, 1930 and on Vieques Island, April 28 to 29, 1930. In Porto Rico we have reared adults from dry pigeon pea pods from Río Piedras, Bayamón, Vega Alta, Vega Baja, and Cabo Rojo and from dry crotalaria pods from Pueblo Viejo and Bayamón.

The pupal period has lasted in specimens we have reared from 9 to 11 days. All the pupae which we have seen have formed within the pods at or near one end, in a tough silken cocoon.

PARASITES. In the first lot of pigeon pea pods which we found infested with Brachyacma a number of Proctotrupids emerged from one full-grown larvae. These were determined by Mr. Gahan as Paralitomastix n. sp. We later found on examination that many of the mature larvae contained parasites of this species. The larvae of the parasite completely fill the body of the host and pupate within it, all of the adults emerging within a few hours of each other. Our observations indicate that over 50 percent parasitism may occur and in one case 8 out of 11 larvae examined were parasitized. The adults emerging from any given larvae are either all males or all females as is usual with polyembryonic species. Our records show that as few as 37 and as many as 134 adult parasites emerged from a single host larvae with an average of 71 per host larva. In several of these cases, however, some of the parasites had failed to emerge, in one case 25% of the total number of parasites present remaining within the body of the host.

Pigeon peas are of course an important source of food in Porto Rico and are widely grown in all parts of the island. Since seed for the next

crop is obtained from dry pods left on the vines, this pod-borer is responsible for more or less reduction in the seed crop. As the insect has been little observed in Porto Rico up to the present time no one has thought remedial measures to be necessary.

Other Lepidopterous Borers

Heliothis virescens Fab. We have repeatedly found the larvae of this well known pest of tobacco in Porto Rico eating large holes in the pods of pigeon peas. Often partly grown larvae have been found entirely within the pods where they were feeding on the seed. We have reared a number of moths and found the pupal period to last from 9 to 13 days.

Heliothis obsoleta Fab., which is well known in Porto Rico was intercepted in two shipments of string beans from Río Piedras in December, 1929, on the dock at San Juan.

Laphygma frugiperda S. and A. Cotton (Jour. Dept. Agr. P. R. 2:289, 1918) states that the larvae of this insect are frequently found boring in the pods of string beans.

Ancylostomia stercorea Zell. On August 11, 1930 we collected a few dry pods of pigeon peas in St. Thomas which were infested with a Lepidopterous borer. But a single adult was later reared which was determined for us by Dr. W. T. M. Forbes who writes that he has it also from Río de Janeiro and that he caught a series of the moths at light in April 1930 at Puerto Real on Vieques Island, P. R. This latter is apparently the only record for Porto Rico. The St. Thomas specimen pupated on August 16 and the adult emerged Sept. 1.

Utethesia ornatrix Linn. is extremely abundant in Porto Rico, boring in the pods of Crotalaria. We have been told that this species is sometimes responsible for substantial reduction in the seed crop which has considerable commercial importance for export.

President Franklin Sherman: We will now listen to the next paper.

STUDIES OF *EUTETTIX TENELLUS* BAKER IN 1930 IN SOUTHERN IDAHO

By P. N. Annand, J. C. Chamberlin, G. F. Henderson, and H. A. Waters, *Twin Falls, Idaho*

(Withdrawn for publication elsewhere)

President Franklin Sherman: I will now call for the paper by Alvah Peterson.

SOME NOTES ON THE REFRIGERATION OF INSECT EGGS PARASITIZED BY *TRICHOGRAMMA MINUTUM*

By A. PETERSON, *Columbus, Ohio*

(Paper withdrawn for publication later)

MR. PHILIP GARMAN: Have you compared the adult Trichogramma, that is those coming from the bagworm and those from the peach moth, in the open?

MR. ALVAH PETERSON: Yes, their size all depends on the number of parasites coming from a peach moth egg. If one adult develops in a peach moth egg you will have an adult that will be as large as an adult developing in a bagworm egg. If you get two or three, or more, there will be a reduction in size.

MR. W. E. HINDS: Has Mr. Peterson any information as to the temperature that these Trichogramma will pass through on the bagworm eggs?

MR. ALVAH PETERSON: As low as freezing. Until recently we have not had equipment necessary for studies below this point. We are conducting tests along that line now.

MR. W. E. HINDS: Have you any evidence as to how they survive the winter up there?

MR. ALVAH PETERSON: I have wintered Trichogramma in three species of insect eggs, fruit moth eggs, eggs of the Mediterranean flour moth, and eggs of the bagworm. All were kept out-of-doors in a screened insectary. No egg will survive the winters, as far as Ohio and New Jersey conditions go, unless the egg is parasitized late in October or early in November. These give rise to adults late in April or early in May. Eggs parasitized previous to October 15 are apt to produce adults during warm periods in December and January.

PRESIDENT FRANKLIN SHERMAN: The next paper is by D. M. DeLong.

DISTRIBUTION OF THE POTATO LEAFHOPPER (*EMPOASCA FABAE* HARRIS) AND ITS CLOSE RELATIVES OF EMPOASCA

By DWIGHT M. DELONG, *Columbus, Ohio*

ABSTRACT

At least four species of *Empoasca* occurring on truck crops in the United States have been designated under the name *E. fabae* and confused until recently. A study of the crops which they infest and the conditions under which they occur indicates that they cause economic damage and are distributed for the most part in different areas. *E. fabae* is a low altitude humid species occurring in the eastern U. S. *E. filamenta* is a high altitude arid species and occurs in the intermountain region of western U. S. *E. abrupta* and *arida* are low altitude arid species and occur on the Pacific Coast in abundance.

For many years we have considered the potato leafhopper (*Empoasca fabae* Harris) as the only important species of *Empoasca* occurring on truck crops in the United States. This idea has probably been due to the fact that the species of the genus *Empoasca* closely related to the potato leafhopper are so similar in color, markings, size and appearance that they could not be separated with any assurance into specific groups upon the basis of these characters. In fact several species have not previously been described because these characters were not distinctive.

Also authentic field observations in certain areas have been almost entirely lacking. Recent field and laboratory studies have revealed the fact that at least four species are of major importance on truck crops in the United States. In the past these have all been designated as the potato leafhopper and placed under the scientific name of either *Empoasca fabae*, or *Empoasca flavescens*. The latter species is European and no authentic American records have thus far been established.

Studies by the author and others[1] have indicated that morphologically and biologically as well as in respect to the type of economic injury, these species are distinct. Heretofore only color and external characters have been used in classification of the species of this genus and these are not sufficiently constant nor distinctive to use for specific separation. Excellent characters for distinction have been found however in the genital chamber of the male. These chitinized pieces are usually designated as internal genitalia. The lateral processes and the dorsal spines of the pygophers have indicated excellent characters for separation. These have been discussed in the bulletin cited above.

By use of these characters and field observations it has been found that in addition to the potato leafhopper *Empoasca fabae*, at least three

[1]D. M. DeLong Tech. Bul. 231. U. S. D. A. Bur. Ent. Jan. 1931.

and probably four other species are major pests of truck crops in the United States. They are *E. filamenta*, *E. abrupta*, *E. arida*, and probably *E. cerea*.

Distribution of Hopperburn and of Empoasca Fabae. For the past few years it has been the general opinion that hopperburn does not occur except in the eastern half and the southern portions of the United States. This knowledge led the writer to an investigation of the species of the genus Empoasca with special emphasis upon those occurring on truck crops.

The potato leafhopper, *Empoasca fabae* Harris, is well known to be an important pest throughout the eastern and southern United States, injuring especially potatoes, beans and eggplant in addition to such crops or plantings as clover, alfalfa, cotton, rhubarb, dahlias and apples. As has been pointed out previously, the type of injury will vary with the kind of crop but the most important type of injury is known as hopperburn and occurs upon certain truck crops especially.

Recent population studies in the western United States[2] have shown that *E. fabae* occurs westward to the Rocky Mountains in Colorado but at these high elevations east of the mountains (3500 to 4500 ft.) occurs in such small numbers that it is not of importance economically. It also probably occurs in the states of the southwestern U. S. and is found in southern California. Although recorded for several localities in the southern portion of California, it is present only in small numbers on bean and alfalfa with an occasional chance occurrence upon such crops as tomatoes and spinach. In no place in the western United States, however, were the populations of sufficient size to cause economic injury and no hopperburn was found west of approximately the 100th meridian. It is apparent that regions of higher elevation or arid conditions are not favorable to the production of large populations by this species. No specimens could be found in the high intermountain area between the Eastern Rocky Mountains and the Sierra Nevadas. The individuals are very scarce at even slightly high altitudes, while in the arid southwest and in California they have been found in small numbers and only at low altitudes. The eastern half and the southern United States are therefore the areas of importance so far as injury is concerned in the case of *Empoasca fabae*. The distribution of these species is shown in Figure 38.

Western Truck Crop Species. From the economic point of view three other species of major importance replace *fabae* in the higher alti-

[2]This was made possible through the kindness of J. E. Graf and P. N. Annand of the Bureau of Entomology, U. S. Dept. of Agriculture.

tudes and arid regions of the west. *E. filamenta* is abundant throughout western Colorado, Utah, Idaho, Nevada, Oregon, Wyoming, and southern Montana on potatoes, beans and sugar beets especially. It is practically the only species of Empoasca which occurs in this region on economic crops and it might be designated as an intermountain leafhopper since its area of importance is between the eastern range of the Rocky Mountains and the Sierra Nevadas of California. It has been collected in many localities in California upon sweet potatoes, carrots, squash, tomatoes, egg plant, artichokes, cucumbers and Japanese parsnips, as well as alfalfa. In this area, however, the populations were all

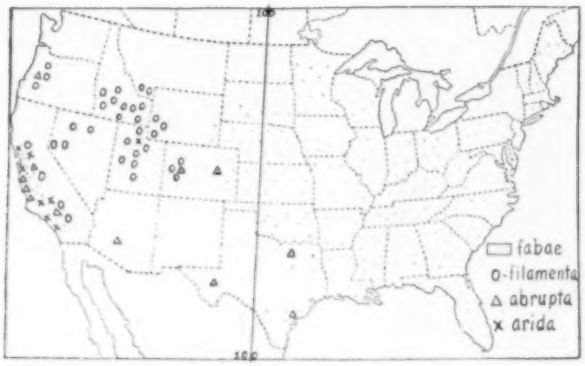


FIG. 38.—Areas of the U. S. in which the more important species of Empoasca are known to occur.

very small except upon sweet potatoes in one area. There is therefore no indication that it is an important species in California and its status is similar to *fabae* in the California area although it is slightly more abundant in numbers and wider in distribution. While a western species it is apparently a high altitude species occurring abundantly on crops growing at 4000 to 6000 ft. elevation, but it seems to be very scarce at altitudes of less than 1000 ft.

Two other species, *E. abrupta* and *E. arida* are the most important on truck crops in California. Both occur in injurious numbers although *E. abrupta* is more wide spread and the populations are much greater on several different crops. This species apparently obtains its greatest population development upon the cucurbit group of plants and enormous populations were found in certain areas upon cantaloupe, casaba and honey dew melons. It also was found in abundance upon various types of squash, cucumber, watermelon, potatoes, different varieties of beans,

parsnips, sweet potatoes, okra and celery, and in smaller numbers upon turnips, Japanese parsnips, peppers, tomatoes, sugar beets, garden beets, lettuce, artichokes, egg plant, and gherkins. In addition such crops as alfalfa, corn, cotton and sunflowers show considerable populations.

The largest populations of *E. arida* are found on potatoes and sugar beets. Next in abundance are beans and squash and small populations occur on lettuce, parsnips, carrots, Chinese cabbage, cucumbers, celery, egg plant, Swiss-chard, tomatoes and alfalfa.

In addition to the California area where it is one of the two predominant species, *E. abrupta* has been found in Texas, Arizona, Oregon and in small numbers occasionally in Colorado. Also *E. arida* has been taken

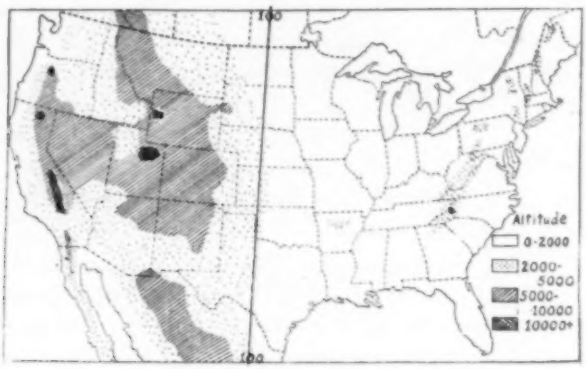


FIG. 39.—Diagram showing different elevations in areas of the U. S.

in small numbers in local areas in Utah. Although *abrupta* was collected in western Colorado at elevations of 4600 feet and both *abrupta* and *fabae* were collected in Eastern Colorado at elevations of 4600 feet, they were found in very small numbers upon potatoes and no injury was evident

Another species, *E. cerea*, has been collected in north central Utah and has been taken in small numbers in California from sugar beets, lettuce, green beans, okra, and carrots. It apparently is not a species of importance at the present time.

The economic species of Empoasca occurring in the United States on truck crops together with the areas of their importance might be summarized thus; *E. fabae* in the eastern half and the southern U. S.; *E. filamenta*, in the west central or intermountain area and *E. abrupta* and *E. arida* are predominately California and west coast species. An examination of conditions existing in these areas shows that *E. fabae* is a low

altitude, humid species, while *E. filamenta* is a high altitude, arid species and *E. abrupta* and *E. arida* are found with few exceptions only in low altitude arid regions where they become very abundant. A comparison of the "elevation" map and "distribution" map will show this rather clearly.

DIFFERENT TYPES OF INJURY. *Empoasca fabae* causes hopperburn on potatoes, egg plant, rhubarb and dahlias, stunting or dwarfing on beans, yellowing on alfalfa, and reddening on clover. It is apparent that this type of injury is not caused by the three western species, *E. filamenta*, *E. abrupta* and *E. arida*. Field observations have shown that where these species are abundant the leaves show some form of white spotting or a white stippled injury. Cantaloupes, beans, potatoes and other crops in the irrigated areas in Utah, Idaho and California have shown conspicuous injury by these insects due to a loss of chlorophyll.

EASTERN SPECIES PREVIOUSLY CONFUSED WITH E. FABAE. Several writers have referred to wild host plant records in connection with the discussion of the occurrence of *fabae* on truck crops in early spring. It is apparent from data collected during the past five years that such records have been concerned chiefly with *E. erigeron* and E. *bifurcata* instead of *fabae*. *E. erigeron* occurs on *Erigeron annuus*, *E. canadensis* and other wild hosts overwintering as an egg and is on the wing early in the spring at the same time or slightly before *fabae* is active in the field. *E. bifurcata* occurs on tansy and related plants and both have been confused for years with *fabae*. Also other species of minor importance like *solana* have been confused with *fabae*. Therefore, unless material used by these workers has been retained which can be examined at the present time, these data cannot be depended upon as authentic records of the spring occurrence or activity of *fabae*. Personal observations in the field have shown that when a green Empoasca leafhopper appears upon a wild host plant in early spring it cannot be assumed, as has been the custom in the past, that it is *fabae*, even though it resembles *fabae* in size, appearance, and coloration. Furthermore collection and examination of this material has revealed the fact that almost every specimen is either *E. erigeron* or *E. bifurcatus*.

PRESIDENT FRANKLIN SHERMAN: We will now listen to a paper by D. F. Farlinger and C. H. Alden.

THE ARTIFICIAL REARING AND COLONIZATION OF *TRICHOGRAMMA MINUTUM*

By C. H. ALDEN and D. F. FARLINGER, *Georgia State Board of Entomology*

ABSTRACT

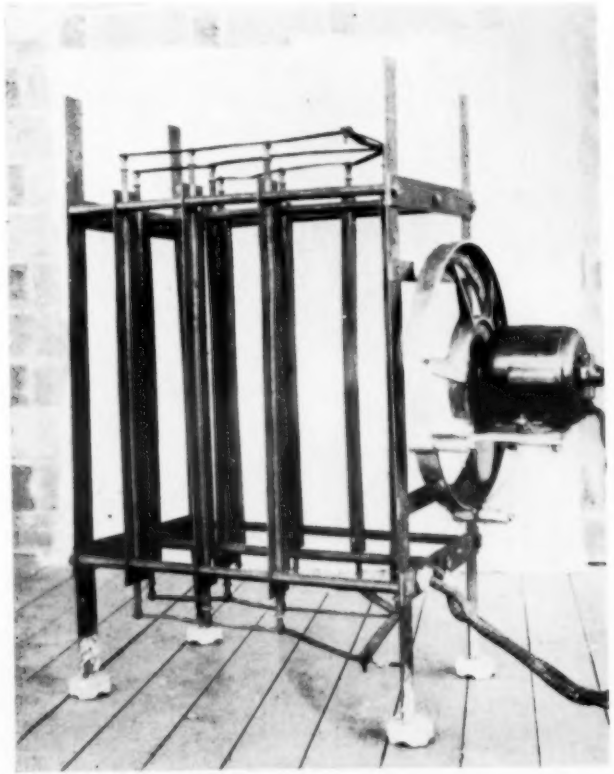
This paper gives the results of two years' experiments on rearing and colonizing *T. minutum* on peach, apple and pecan insects in Georgia. *Sitotroga cerealella* is used as the laboratory host. Field hosts are Oriental fruit moth, codling moth, nut case bearer, leaf case bearer and shuck worm eggs. A new type of parasite card is described. Some very promising results were obtained in the field, especially in parasitizing the eggs of the Oriental fruit moth and codling moth.

Artificial production of *Trichogramma minutum* Riley was started at the Fruit Pest and Parasite Laboratory of the Georgia State Board of Entomology in January 1929. On account of the lack of adequate spray control for the Oriental fruit moth (*Laspeyresia molesta* Busck) and the pecan nut case bearer (*Acrobasis hebescella* Hulst) and the need of supplementary control measures for the codling moth (*Carpocapsa pomonella* L.), it was decided to erect a laboratory to produce and colonize *T. minutum*.

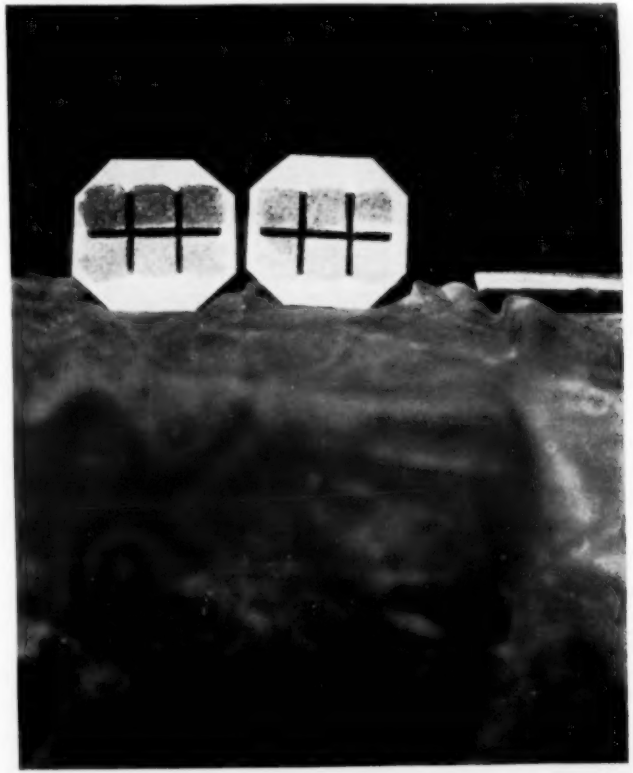
The equipment and methods used are very similar to those used at the Louisiana Experiment Station. The laboratory is of brick, constructed with hollow walls to form a dead air space. It contains four rooms; two moth breeding rooms, one parasite room and an office. The breeding rooms are insulated with sheet rock on sides and ceiling and have double windows. The windows and doors are padded with felt to secure as tight a fit as possible. The windows in the breeding rooms are screened with sixty-mesh copper wire screening. The temperature in these rooms is kept at approximately 80 degrees F. by means of automatic electric heaters. (See Plate 15). These heaters are made up of ten 500 watt Helicoil air heating units in each room. A high speed fan is bolted to one end of the frame containing the heating units. This fan drives a blast of air over the heating elements, thus circulating hot air over the entire room. Both the heaters and fans are operated by General Electric magnetic switches controlled by thermostats. This equipment has been very satisfactory and almost uniform temperatures can be maintained during the coldest weather.

Each room has a rack containing sixty-four trays. These racks are nine feet three inches long, five feet ten inches wide and six feet one inch high, outside measurements. The trays are twenty-three and three-fourths inches wide, thirty-two and three-fourths inches long and four inches deep and contain approximately one bushel of corn. There are eight trays in a tier and four tiers to each side of the rack, making

Plate 15



Automatic electric heater



Parasite card

approximately sixty-four bushels of corn in each room. The relative humidity is normally around fifty to sixty percent. However, in the middle of the summer it gets lower necessitating sprinkling.

The moths are collected every morning by means of a vacuum cleaner combined with a special moth collector. Six to eight thousand are collected in a battery jar which is then covered with twenty-mesh wire screening. The moths oviposit in the scales and debris in the jar and the eggs are screened out daily. After cleaning, the eggs are stuck on cardboard with Cico paste, allowed to dry and exposed to the parasites.

The parasite cards are seventy-five millimeters square and are divided into six sections of twenty square millimeters each. (See Plate 15). This enables the card to be cut up without destroying any eggs. There are approximately twenty-five hundred eggs on each section, making a total of fifteen thousand eggs on each card. Small pieces of cork are stuck to the under surface of the card so that the eggs will be near the top of a petri dish, which is used to confine the parasites while they are ovipositing in the host eggs. The vents in the card between each section allow more light to enter the petri dish and thus speed up emergence of the parasites and allow them to come up through the vents to the host eggs at the top of the dish. Humidity is increased in the petri dish by means of a small piece of damp blotting paper. The dishes are set at an angle on shelves before a window so that the light is generally diffused over the entire surface. Four to six fold multiplication is expected. Higher rations have been used but the percentage of parasitism decreases in proportion to the increase in ratio.

During the spring of 1929, there was a severe infestation of a Gamasid mite in the breeding rooms. The mites were so numerous that the moth production was affected and the egg laying average greatly lowered. After a good deal of correspondence with other laboratories in regard to mite suppression, it was decided to try dusting super-fine sulfur in the rooms. Accordingly, a heavy application of sulfur was made in all trays in each room. The mites were almost completely eliminated and the sulfur apparently had no effect on *Sitotroga cerealella* as the stock of moths began increasing. However, when eggs from the moths in this sulfured corn were exposed to *T. minutum* they practically refused to oviposit in them and only ten to twelve percent parasitism could be secured. The parasites reared from these eggs were sluggish and died in about twenty-four hours after emergence. The particles of sulfur which adhered to the moths as they worked their way up through the corn in the trays, were mixed with the eggs in oviposition cages and acted as a repellent to the parasites. Therefore, the sulfured corn had to be

discarded, the rooms stocked with fresh corn and a new supply of moths produced. Excellent parasitization was secured with eggs from moths in sulfur-free corn.

About the middle of August, an infestation of *Habrocytus cerealellae*, a larval parasite of *S. cerealella*, was noticed in the breeding rooms. This caused a retarding of moth production but did not entirely check it.

During August and September 2,500,000 parasites were reared. There were colonized 1,400,000 of these parasites in peach, apple and pecan orchards of the state. Owing to the lateness of the season, not enough host eggs were recovered in the field to give any definite data on results to be expected.

Production of *T. minutum* was started again in April 1930. From then until the middle of August, when another infestation of *H. cerealellae* practically stopped moth multiplication, over 8,000,000 parasites were reared. Over 7,000,000 of these were produced in May, June and July. There were reared 2,010,000 in May; 3,350,000 in June; and 1,785,000 in July. The excessive heat during the latter part of June and in July, when the maximum was over 100 degrees F. on two different occasions, seriously affected the moths in the breeding rooms. A high percentage of the eggs were sterile and very few moths emerged from the trays of corn. When these high temperatures occurred, the moths stayed in the corn as it was somewhat cooler there than on the walls of the breeding rooms. The moth supply and corresponding egg recoveries, fell off rapidly. The rice weevil (*Calandra oryzae* L.) and the rust red flour beetle (*Tribolium ferrugineum* Fabr.) increased rapidly in the high temperature and destroyed great quantities of corn in the trays. The rust red flour beetle also fed on Sitotroga eggs and the dead bodies of the adults. Consequently, the moth supply was very low by the middle of August when *H. cerealellae* was first noticed in the breeding rooms. This parasite practically destroyed its host (*S. cerealella*) by the middle of September.

During the winter of 1930–31 the laboratory will be made as nearly insect proof as possible, by filling all cracks with plastic wood. A double fumigation at twice the required dosage each time will be given the entire building with a Cyanogen chloride gas mixture.

Colonizations were made this year in practically all of the peach, apple and pecan sections of the state. Experiments conducted in peach orchards of the Cornelia district which is in the mountainous section of northeast Georgia, proved it to be useless to colonize *T. minutum* prior to June 1. Although there is a limited supply of Oriental fruit moth eggs available in May, the nights are generally so cool that the parasite cannot establish itself satisfactorily. In central and southern Georgia,

Plate 16

Trichogramma minutum

UNIV. OF MICH.

colonizations can be made several weeks earlier. In a peach orchard where these parasites were liberated on July 3, parasitized Oriental fruit moth eggs were recovered on July 7. There were recovered 31 eggs; 17 of them were parasitized or 54.8%. Parasitized eggs were recovered eighty feet from the point of liberation. At various times throughout the summer, the adults were observed on peach foliage. (See Plate 16.)

T. minutum was colonized in pecan groves as a natural control for the nut case bearer and leaf case bearer. The year 1930 was the first in which extensive colonizations were made in pecan groves and further experimental work is necessary before any conclusions can be given. It was definitely established, however, that the parasite would attack the eggs of both the nut case and leaf case bearers, although the percentage of parasitism was low on the first brood eggs in 1930.

The following tables show the recoveries and percentage of parasitism of Oriental fruit moth and codling moth eggs. In several instances, a portion of the unhatched eggs were found to be parasitized by holding at the laboratory. The average percent parasitized from collections made on three broods of the Oriental fruit moth eggs, was 47.2% and on third brood codling moth eggs was 70.4%.

TABLE 1. *T. minutum* RECOVERIES IN PEACH ORCHARDS. HOST, ORIENTAL FRUIT MOTH

Date recoveries	Brood O. F. M.	Total Eggs	Parasitized	Empty shells	Unhatched eggs	Total parasitized	Per cent parasitized
7/7–7/14	3rd	183	59	98	26	66	36
7/28–8/28	4th	133	64	43	26	79	60
8/3	5th	67	36	31	0	36	53.7
Totals		383	159	172	52	181	47.2

Third and fourth brood eggs collected at Cornelia; 5th brood at Thomaston, Georgia.

Recoveries were made on third brood codling moth eggs. No parasites were liberated at the point of recovery this year, colonization being made in the fall of 1929 about three-fourths mile distant. These data indicate a winter survival of the parasites in addition to its effectiveness in 1930.

TABLE 2. *T. minutum* RECOVERIES IN APPLE ORCHARDS. HOST, CODLING MOTH

Date recoveries	Brood C. M.	Total eggs	Parasitized	Empty shells	Unhatched eggs	Total parasitized	Per cent parasitized
8/12.....	3rd	396	197	177	22	215	54.3
8/13.....	3rd	462	339	113	10	341	73.8
8/14.....	3rd	524	411	106	7	417	79.4
Totals..		1382	947	396	39	973	70.4

PRESIDENT FRANKLIN SHERMAN: T. E. Bronson will now present his paper.

EFFECT OF PROTECTIVE COVERING UPON THE OVER-WINTERING OF EGGS OF THE PEA APHID, *ILLINOIA PISI* KALT.

By T. E. Bronson, *Madison, Wisc.*

(Withdrawn for publication elsewhere)

President Franklin Sherman: The next paper is by G. E. Gould.

PANGAEUS UHLERI, A PEST OF SPINACH

By George E. Gould, *Virginia Truck Experiment Station, Norfolk, Va.*

Abstract

A Burrower-bug, *Pangaeus uhleri* Sign., was observed attacking spinach as the seedlings were pushing through the ground. Although the infestation was confined to a few fields, the seriousness of the injury this year shows that the insect is sometimes of economic importance. Several unusual habits of the insect are recorded.

Early in September 1930, a report of an unusual type of insect attack upon seedling spinach was received. The complaint came from a grower near Norfolk and his story was so unusual that an immediate investigation was started. The insect making the attack was a small black burrower-bug, which was later determined by Mr. Paul Oman as *Pangaeus uhleri* Sign. A review of the literature revealed the fact that this insect has not been reported previously as causing damage to cultivated crops. The first examination of the fields revealed enormous numbers of these burrower-bugs scrambling about over the loose soil of the spinach beds. At that time very few spinach plants were seen above ground and further examination showed that only a few more would ever come through. The seed would apparently germinate but shortly after the cotyledons were out of the seed coat, these insects would attack them. The method of attack consisted of inserting the beak into the stem close to the seed coat and sucking the sap, the result being a withered and dying plant which could not push through the ground.

The habits of these interesting little bugs were observed in some detail. They were seldom seen in bright sunlight, and would run rapidly from one clod to another, or would dig into the soil for concealment if no lumps were present. A decided preference was shown for hiding in the cracked earth caused by the germination of the seed. As many as 20 or 30 could be counted to the inch of row and all were apparently attempting to reach the seeds. Those plants that were strong enough to push through the surface were seldom molested.

Another interesting performance noted was the attempt of the bugs to carry off the seed-coat of the attacked seed. Several bugs, both

nymphs and adults, would cluster around the seed and slowly roll it away. The number engaged in such an attempt was usually four or five, although as many as twenty were sometimes counted. The bugs would gradually move the seed-coat to a point suited to their purpose and there bury it in the ground. If disturbed most of them would turn loose the seed-coat and immediately dig out of sight into the loose soil.

The grower could give no explanation of this sudden appearance of such large quantities of bugs. They were noticed first in July when the bugs appeared to be migrating from a nearby woods. The farm laborers reported them to be "marching across the roads and paths like army worms." The grower paid no attention to these stories until September when he noticed he had failed to obtain a stand in certain fields. It was at this time that he called our attention to the bugs.

An examination of the various fields showed the spread of the insects from a distinct center of infestation—the neighboring woods. There were in all about twelve fields of spinach on the farm, separated only by roads or by drainage ditches. The field nearest the woods was the first to be infested and at the time of our first visit this had been worked over and re-seeded. Of the three fields adjoining the first, not over fifteen per cent of the plants in two of them had withstood the attack of the bugs, while the third had about half of a commercial stand. In this field the bugs were still numerous and active. Several of the neighboring fields had a small population, but not sufficient to be markedly injurious.

No explanation is offered for this sudden outbreak of this little-known insect. All fields had produced a spring crop of radishes, many of which were harvested, but of course, some remained in the field until the land was plowed in August. The spinach seed was sown immediately after the plowing. Two fields were fertilized with stable manure, but this did not affect the subsequent infestation. There is a possibility of some correlation between the appearance of these bugs and the exceedingly dry season of 1930.

DESCRIPTION OF THE INSECT. *Pangaeus uhleri* is a black or sometimes reddish brown bug, 6.5 to 7.5 mm. in length and about 3 mm. in width across the pronotum. The legs are brownish-black with the femur armed with numerous stout spines. The scutellum is flat and somewhat triangular, extending caudally about half the length of the abdomen. The nymphs, which were the most abundant form early in September, are blackish or reddish-black in color, with light areas on the dorsum of the abdomen.

RELATED INSECTS: Since no reference to this insect was found in economic literature and the situation demanded immediate action, records of related insects were sought in hopes that a remedy might be suggested. *Pangaeus bilineatus* Say was reported by Watson in Florida (Fla. Agri. Exp. Sta. Bul. 151) on strawberries; by Ogilvie in Bermuda (Bermuda Rept. Dept. Agr. 1925) on strawberries; and by several other authors as a pest of berries. A negro bug, *Thyreocoris pulicarius* Germar, has caused much damage to celery in Michigan and Ohio and is noted for causing the foul taste of raspberries and blackberries over which it crawls. Control measures suggested for these two insects are repellents such as sprays of carbolic acid mixture or of strong nicotine-soap.

PLANS FOR CONTROL. Since both measures used for the negro bugs would be ineffective against insects that work underground, a suggestion was offered that the seed might be treated with a substance either poisonous or repellent to the insects. An experiment using various materials was started, but the exceedingly dry condition of the soil did not allow germination of the seed until long after all bugs had disappeared. Spinach seed planted in the fields September 15th finally came through the ground about October 15th with a good commercial stand.

The seriousness of this insect is a matter of conjecture, but the infestation indicates that under favorable conditions it could become a pest of major importance. This season it was found on only one farm, where it infested in injurious numbers over half of the fields devoted to spinach. This grower plowed up and replanted 43 acres of spinach on account of the injury caused by this insect.

PRESIDENT FRANKLIN SHERMAN: The next paper is by Leonard Haseman.

OBSERVATIONS ON THE WINTERING HABITS OF THE STRIPED CUCUMBER BEETLE[1]

By LEONARD HASEMAN, *Columbia, Mo.*

ABSTRACT

Observations are reported which indicate that the adult striped cucumber beetles (*Diabrotica vittatta*) feed on green cucurbit fruits and the blossoms of weeds and flowers long after the first killing frosts destroy the natural food crops. In cage experiments the beetles collect in bunches beneath green as well as dry grass and other vegetation supplied as coverage, but they do not burrow into the ground.

At one of the recent meetings of this society the question was asked, "where and under what conditions does the striped cucumber beetle pass the winter." From the discussion which followed it was apparent

that very little was really known concerning the whereabouts of this common pest during the winter months. Publications on the pest usually state that the adult beetles live through the winter under rubbish and other protection. The writer at the time reported that in large melon fields in Missouri heaviest infestation the following summer had been observed to occur in the vicinity of large trees with surrounding tracts of uncultivated ground out in the melon fields. This is an important pest of cucurbits in the home garden, as well as in commercial melon and canteloupe growing areas. The question of the pest's whereabouts during the winter months is a pertinent one and, so far as the writer has observed, no one has yet come forward with a conclusive answer[1].

Missouri grows a considerable acreage of watermelons and for a number of years the department of entomology has had this and the other melon pests under investigation. While the practical applications of different insecticides to protect the young plants from the destructive work of the beetles has received most attention, observations on the biology and behavior of the beetle have been made.

Feeding Habits of the Beetle. It is a well known fact that after the young plants have begun to vine and bloom the beetles turn their attention more particularly to the pollen and other soft portions of the blossoms. Later in the fall the beetles will also be found in great numbers feeding on the pollen and other portions of the blossoms of wild and cultivated sun-flowers and on the blossoms of various composites. After killing frosts, when most vegetation is gone, they turn to the immature fruits of squash, pumpkin, and melons. So great may be their numbers on these green fruits that they may practically devour them before increasing cold drives them to their winter harbors. This year they continued to feed on such fruits until the last days of November, and in breeding cages on warm days since then they have continued to move about and do some feeding on the dried or decaying remains of squashes. It is evident that these beetles require food under Missouri conditions until cold weather drives them to winter quarters, and limited observations this winter indicate that they may do some feeding during warm spells after winter has set in. Beetles taken into the laboratory turned to dandelion blossoms and fed greedily as soon as they thawed out. During the fall of 1929 and again in early breeding cage work this fall the beetles all died, due to the lack of food after killing

[1]Since the preparation of this paper the writer's attention has been called to reports on the hibernation of the striped cucumber beetles by Balduf, Ent. News, 40, 260–262, 1929, and Gahn, Jr. Econ. Ent., 22, 603. 1929.

frosts. This fall, however, later collections placed in cages with food have gone into winter conditions and up to the middle of December seemed to be hale and hearty.

Field Studies During the Winter. During the winter of 1928 and early spring of 1929 an effort was made to collect the beetles in their winter harbors. Observations were made in the vicinity of what had been a large planting of cucurbits, which were heavily infested in the fall. Beds of leaves and other dry and moist plant debris along fences, roadsides, wood lots, and the grassy drives were carefully examined. Brush piles, bark of trees and logs, and dry grass clumps were examined. Diggings were made in the melon field and nearby. Plant debris which should serve as winter protection was brought into the laboratory to thaw out and not a beetle or even a striped wing cover was found. In the spring pots of young squash plants were distributed in different places about the field in hopes of finding where the first and the most beetles would show up. This, likewise, gave no clue as to their winter nests. It almost looked as though none of the thousands of beetles which were present when winter set in actually spent the winter in the same neighborhood. However, in due time in the early summer of 1929 thousands of beetles were again on hand. Plenty of them safely passed the winter in the neighborhood. The winter of 1929 was severely cold and in spite of the fact that the beetles were very abundant in the fall, few appeared on the young plants in the early part of the season of 1930. They evidently pass the winter under conditions which permit a severe winter to greatly reduce their ranks.

Breeding Cage Studies. During the fall of 1930 a series of breeding cage experiments were undertaken. The cages were placed over different types of shelters. Blue grass, bare ground and dry grass, squash vines, bark, paper, and other types of coverage were used. Small green squashes were given as food and the beetles continued to use it on warm days until about the first of December. During the second and third week in November on sunny afternoons the caged beetles crawled and flew about in the cages in an effort to get out. On the other hand, beetles from the garden came to the cages and attempted to get into them. The cages were heavily stocked with beetles which may have accounted for their restlessness. After a few days as it grew colder they settled down, going beneath the vegetation to hibernate. Most of the beetles feeding in the open on frosted squashes on those same warm afternoons left the squash patch for winter quarters. However, even after it was cold enough to freeze the ground, the beetles would collect in small

bunches underneath the squashes for the night and the next afternoon crawl out and feed on the squashes.

How the Cage Specimens Have Prepared for Winter. In the cages the beetles continued to feed ravenously until cold weather during late November and early December put a stop to it. Then they went beneath the protection provided in the cages. Examinations made during December showed the beetles collected, as a rule, in clusters beneath the vegetation but not beneath the soil. In some cases a dozen or more would be closely clustered together and at that time very few dead specimens were found. In the cages both the striped and the spotted cucumber beetles were used and they both showed the same tendency to form in clusters on the ground beneath the protection. With the winter well advanced, it is quite likely now that these beetles will go through the winter in their present locations, but they will be kept under observation throughout the winter and early spring.

This tendency to collect in clusters was first noted early in the fall when the nights began to turn cold. They would collect in bunches beneath the green squashes and the frosted squash leaves, and under fallen tree leaves. In the spring it is also a common habit of these beetles to congregate in great numbers around certain hills of young plants, while other hills may have few or none attacking them. They seem to be gregarious in habits and if this holds in nature during the winter it would help to explain the difficulty of actually locating them in their winter quarters. In cages with both growing blue grass and dry vegetation, the beetles were observed to be most abundant beneath the green blue grass. If blue grass or other grassy harbors should prove to be their natural winter home, there is always plenty of such protection near gardens and melon fields.

From present indications the striped cucumber beetles seem to be at home collecting in clusters beneath the protective vegetation resting on the soil but not burrowing into the soil. In the open it is yet to be shown just what type of plant coverage proves most attractive for the overwintering beetles.

Mr. W. V. Balduf: I would like to call attention to a short article that was published a few years ago in the Entomological News on this subject. The hibernation of this species has long been regarded as unsolved.

About two years ago while tramping through the woods one afternoon, I discovered above 50 cucumber beetles in hibernation during January or February under a thick mass of leaves along the margin of the woods.

The nearest cucumbers had been growing perhaps a quarter of a mile away. It is possible that the beetles may have come from there. They were under several inches of foliage. They did not burrow into the soil but took advantage of loose accumulation of litter on the ground in order to hide themselves.

PRESIDENT FRANKLIN SHERMAN: This indicates that we are finding out something about one of the essential points in connection with one of our commonest and longest-known insects.

PRESIDENT FRANKLIN SHERMAN. We will now hear a paper by S. Marcovitch and M. V. Anthony.

A PRELIMINARY REPORT ON THE EFFECTIVENESS OF SODIUM FLUOSILICATE AS COMPARED WITH BORAX IN CONTROLLING THE HOUSE FLY (*MUSCA DOMESTICA* LINNE)

By S. MARCOVITCH, and M. V. ANTHONY, *Agricultural Experiment Station Knoxville, Tenn.*

ABSTRACT

Up to the present time, borax is considered the most practical chemical in the treatment of manure for the control of house fly larvae. In a large series of insecticide tests, borax was found inferior to sodium fluosilicate in destroying fly maggots in manure. Neither material was found to possess ovicidal properties. Both borax and sodium fluosilicate act as stomach poisons, producing mortality when treated manure is actually eaten.

Sodium fluosilicate, however, has the advantage of being much more toxic to either larvae or adults. In addition, sodium fluosilicate in amounts up to 300 pounds per acre has no detrimental effect on plant growth, while borax, in very small amounts may prove harmful to certain sensitive plants such as citrus. Since small maggots are more easily poisoned by chemical treatment than are large larvae, best results will be obtained by sprinkling the manure with a saturated solution (1–154) of sodium fluosilicate each day.

As a result of experiments conducted by Cook, Hutchinson, and Scales (1914), borax is considered at the present time the standard chemical for controlling house fly larvae in manure.

A large series of toxicity tests with mosquito larvae and other insects showed borax to be of a low order of toxicity, in comparison with sodium fluosilicate. We, therefore, deemed it worth while to test both materials against house fly larvae in manure.

HISTORICAL. Pioneer work in the chemical control of house fly larvae in manure was begun in 1897 by Dr. L. O. Howard, who concluded that chloride of lime when used in sufficient quantities was an excellent

maggot killer, although air-slaked lime, land plaster or gas lime were impracticable. He also found that 8 quarts of manure sprayed with 1 pint of kerosene, which was afterwards washed down with 1 quart of water, gave good results in laboratory tests, but was impracticable for large-scale use.

Forbes (Howard, 1911) found that lime, borax, borax and sodium arsenate mixture, iron sulphate, and carbon bisulphide—the last in closed-box tests—were effective larvicides.

In 1912, Smith confirmed the kerosene experiments of Howard, by showing that 2 gallons of the liquid sprayed over 25 square feet of manure was decidedly ineffective, as was also 400 pounds of 16 per cent acid phosphate mixed with 2000 pounds of manure. A 4 per cent solution of formaldehyde thoroughly applied to heavily infested manure destroyed very few larvae.

Howard (1915) reported that manure treated with powdered hellebore gave good results. A water extract was prepared by adding ½ pound of the powder to every 10 gallons of water. This stock solution was applied at the rate of 10 gallons for each 8 bushels of manure. Less than ½ pound to 8 bushels was not so effective.

Cook, Hutchinson, and Scales (1914) reported on the comparative effectiveness of several materials, and concluded that borax was the most suitable. However, sodium fluoride was one of the materials tried that showed promise. They recommended applying 0.62 pound borax to every 10 cubic feet (8 bushels) of manure immediately upon its removal from the stable. The borax was applied through a flour sifter or other fine sieve and then 2 or 3 gallons of water sprinkled over the borax-treated manure. They observed that borax proved very effective because of its toxic action on the eggs, and larvae. They also found large numbers of pupae that were black, shrunken, wrinkled, and had the form more of larvae than of pupae. Of these pupae only about 1 per cent hatched.

Experimental

Tests Against Eggs.—A series of experiments was conducted to determine the comparative ovicidal properties of borax and sodium fluosilicate. A large mass of newly laid eggs was divided into 4 parts and submerged in four different solutions, namely: borax 1–30, borax 1–50, sodium fluosilicate 1–154, and water; the latter serving as a check. The vials were shaken so as to insure the wetting of each egg. One-half hour later the eggs were placed on paper which had been moistened with the respective solutions in which the eggs had been submerged. The egg-

carrying papers were placed in salve boxes to await hatching. Nineteen hours later the boxes were examined and counts made. Of 100 eggs which had been submerged in a 1–30 borax solution 96 had hatched, in 1–150 borax solution 98 hatched, in the 1–154 sodium fluosilicate 100 hatched, and in the check 97 hatched.

Since the eggs hatched with this treatment, the experiment was repeated with longer intervals of submergence. In this test the egg mass was divided into 5 parts, the fifth part being placed on moist paper in a salve box for the purpose of determining when the eggs normally hatch. The eggs were immediately submerged upon being found, and at definite intervals 10 eggs were removed from each solution to await hatching (Table 1).

TABLE 1. SUBMERGENCE TESTS AGAINST HOUSE FLY EGGS

Time submerged	Per cent hatched				
	Borax 1–30	Borax 1–150	Sodium fluosilicate 1–154	In water	In air
2½ hrs.	100	80	90	100	—
3½ hrs.	80	100	90	90	—
4½ hrs.	80	90	100	30	—
17 hrs.	90	60	80	90	—
24 hrs.	90	80	90	70	98
41 hrs.	10	40	60	60	—
64 hrs.	0	0	0	0	—

Ninety-eight per cent of the eggs in the check hatched within 24 hours. Submergence in water delayed the incubation period in proportion to the time the eggs were in water.

The percentage of eggs hatching after submergence in either borax or sodium fluosilicate was equal to those hatching after treatment with water. Subsequent submergence tests also showed the same poor ovicidal properties for both borax and sodium fluosilicate.

When either borax or sodium fluosilicate was applied as a dust to eggs on fresh horse manure, or to eggs on a moist paper in a salve box, results were obtained similar to those for the submergence tests.

Since there was a possibility that eggs would be more susceptible to chemical injury at the time of laying than after a few minutes exposure to the air, a method was devised to permit adult flies to deposit eggs on treated manure. One quantity of manure was soaked in a 1–30 borax solution and another in a 1–154 sodium fluosilicate solution. Each portion was placed in a flytrap containing flies. Twenty-four hours later the manure was examined for eggs which were removed to salve boxes. The paper on which the eggs were placed, as well as the camel's hair brush used in transferring, was moistened with the testing solution in order not to dilute the thin film of poison on the eggs. An attempt was

made to select only those eggs that were in contact with the treated manure, avoiding those from the center of egg masses. From a total of 286 eggs laid on manure treated with sodium fluosilicate (1–154), 48.67 per cent hatched; from 492 laid on borax (1–30), 34.03 per cent hatched; and from 50 in the check (water), 26 per cent hatched. The poor hatching qualities as shown in the check may have been due to excess moisture or infertility of eggs. The fact, however, that so large a percentage of borax-treated eggs hatched would indicate that borax has little or no ovicidal properties.

TESTS AGAINST LARVAE.—Nine salve boxes, each containing 50 slightly more than half grown larvae, were filled with manure which had been soaked in a 1–30 borax solution. An equal number of boxes were filled with manure treated in 1–154 sodium fluosilicate solution. A third series was filled with manure treated with water. At the end of 72 hours the boxes were examined for dead larvae and pupae (Table 2).

TABLE 2. THE LETHAL EFFECT OF TREATED MANURE TO SLIGHTLY MORE THAN HALF-GROWN LARVAE

Material used	Dilution	Total number of larvae	Number accounted for	Number larvae alive	Number pupae alive	Number larvae dead	Number pupae dead	Total per cent larvae and pupae dead
Borax solution	1–30	450	403	228	1	174	0	43.17
Sodium fluosilicate	1–154	450	414	133	164	95	22	28.27
Check	Water	450	427	179	182	66	0	15.46

Borax at the high concentration of 1–30 produced 43.17 per cent mortality with large larvae, while sodium fluosilicate (1–154) and one-fifth as strong killed 28.27 per cent. It is interesting to note that 11.82 per cent of the larvae feeding on sodium-fluosilicate-treated manure developed into abnormal pupae. These pupae compared in every detail with those found in borax-treated manure and described by Cook, Hutchison, and Scales (1914). The maximum dilution, however, that will produce a lethal effect on nearly full-grown larvae has not been determined accurately, but preliminary experiments indicate that neither a 1–75 borax solution nor a 1–300 sodium fluosilicate solution will produce mortality.

Since neither borax nor sodium fluosilicate will prevent eggs from hatching, it is important to know the concentration that will prove fatal to newly hatched larvae. To determine this point, 50 eggs were placed on each of variously treated samples of fresh horse manure, a total of 200 eggs being used for each dilution. The dilutions of borax ranged from 1–30 to 1–150, as compared with sodium fluosilicate 1–154 to 1–600. The results indicate that the maximum lethal dilution for borax is between 1

part in 75 to 1 part in 100, while for sodium fluosilicate it is between 1 part in 300 and 1 part in 600. Greater dilutions will not prevent newly hatched larvae from developing in treated manure.

Borax, lime, and sodium fluosilicate were also heavily dusted in boxes, and larvae placed on the dusts. After crawling over the dusts for several minutes, the larvae were placed on fresh untreated manure. Nearly all of the larvae developed, indicating that the larvae must ingest the powder in order to get a lethal dose.

Tests Against Adults.—A solution of sodium fluosilicate was found to be very toxic to adult house flies (Marcovitch, 1929). This suggested that treated manure might have a lethal effect on adults. In order to determine this point, flies were confined in cages with fresh horse manure that had been treated either with a 1–30 borax solution, with a 1–154 sodium fluosilicate solution, or with water. Twenty-four hours later the cages were examined for dead and live flies. The dead flies in the check were negligible as compared with those in the 1–30 borax cages where approximately 50 per cent were dead, or in the 1–154 sodium fluosilicate cages, with approximately 43 per cent dead.

The comparative toxicity of borax with sodium fluosilicate to adults was tested by confining flies in screen cages. Cotton saturated with the respective solution was placed on top of the screen cage, thus giving flies access to moisture and poison; while granulated sugar sprinkled on the bottom of the cage provided food. Counts were made at the end of 24 hours. Each dilution was tested twice (Fig. 40).

At the end of 24 hours the percentage dead for borax was 87 in the 1–30 dilution, 85 in 1–75, and only 10 in the 1–300 dilution. A 1–154 sodium fluosilicate solution killed 74 per cent and a 1–300 dilution killed 77 per cent.

Practical Tests In Horse Stalls.—A few tests were conducted in horse stalls to determine the effectiveness of chemical treatment of manure under practical conditions. Three horse stalls were cleaned thoroughly. Stall No. 1 was sprinkled every other day with 2 gallons of a 1–154 sodium fluosilicate solution. Stall No. 2 was dusted every other day with sodium fluosilicate. Stall No. 3 served as a check. One week later a 560 cc. container was filled with a representative sample of manure from each stall. A count showed that Stall No. 1 had 21 larvae. Stall No. 2 had 303. These larvae were all small, and not a single one of those allowed to continue feeding on the treated manure reached maturity. From Stall No. 3 there were 1194 larvae, which ranged in size from one or two days old to full-grown. The experimental error is necessarily

large due to the method of sampling and to differences in the number of eggs laid in each stall. However, subsequent experiments showed marked control when the sodium fluosilicate was used either as a dust or a 1–154 solution.

Rate of Solution of Borax in Manure.—While making a borax solution it was observed that borax that came into contact with water at room temperature appeared to solidify and become impervious. To

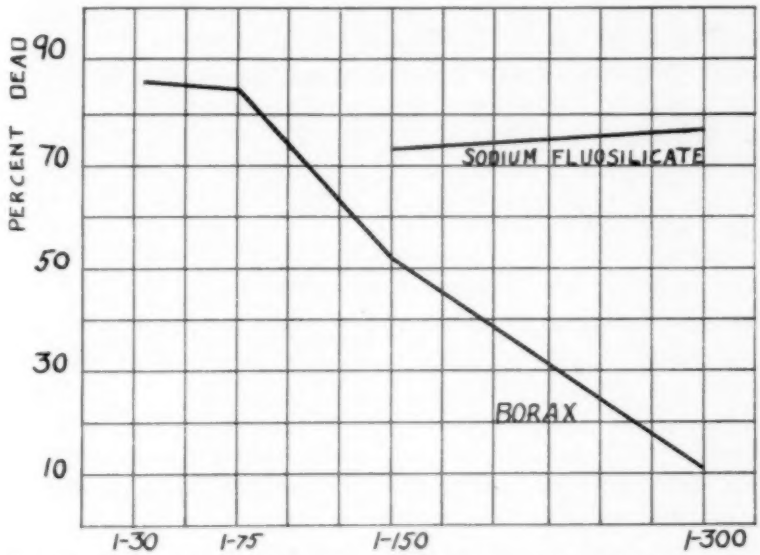


Fig. 40—Toxic curve showing per cent dead adults at the end of twenty-four hours with different dilutions.

determine the amount of borax that went into solution when it was sifted over manure and then sprinkled with water, 5 grams of borax was dusted through a cheesecloth onto absorbent cotton which had been accurately weighed. A 150 cc. application of water was made with a small bottle sprayer. After the water ceased dripping the cotton was so folded as to prevent free borax from escaping and pressure was applied to remove all the solution possible. The cotton was thoroughly dried in an electric oven and again accurately weighed. The difference in weight should be approximately the weight of borax that did not go into solution.

The amount of borax recovered varied from .8 per cent to 35.16 per cent, depending on the number of square inches to which the 5 grams were applied. This experiment indicates that when borax is applied

to manure in dust form and then wetted with water from a sprinkling can, only a portion of the material goes into solution. It would therefore appear that better larvicidal action might be obtained if the borax was first dissolved and the resulting solution sprinkled onto the manure.

THE EFFECT OF BORAX AND SODIUM FLUOSILICATE ON PLANT GROWTH.—Borax used in amounts greater than 0.62 pound for 8 bushels of manure has been shown to injure most plants, while more than 15 tons per acre of manure treated with 0.62 pound to 8 bushels is not recommended (Cook, Hutchison, and Scales, 1914).

Scofield (1930) found that borax in irrigation water in excess of 5 parts in 10,000,000 might prove detrimental to certain plants.

In unpublished experiments at the Tennessee Agricultural Experiment Station, sodium fluosilicate was used in amounts up to 300 pounds per acre without deleterious results, while at 150 pounds per acre it had a decidedly stimulating effect.

CONCLUSION

From these studies we may conclude that the previous conception of borax acting as an ovicide does not appear to hold. Both borax and sodium fluosilicate when used in the treatment of manure for the control of maggots act as stomach poisons. Sodium fluosilicate, however, has the advantage of being much more toxic to either larvae or adults. In addition,, sodium fluosilicate in amounts up to 300 pounds per acre has no detrimental effect on plant growth, while borax, in very small amounts, may prove harmful to certain sensitive plants, such as citrus.

Since small maggots are much more easily killed by chemical treatment than are large larvae, best results will be obtained by sprinkling the manure with a saturated solution of sodium fluosilicate each day.

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MR. F. C. BISHOPP: This is a very important finding in view of the fact that borax, when used continuously on land, when applied with fertilizer is likely to prove detrimental to certain crops. If sodium fluosilicate is not at all detrimental and is even beneficial, it is a decided advantage.

This finished the paper reading session of the Forty-Third Annual Meeting.

Section of Plant Quarantine and Inspection

Tuesday Morning Session, December 30, 1930

The meeting of the Section of Plant Quarantine and Inspection, of the American Association of Economic Entomologists, held in Room 24, Electricity Building, Case School of Applied Science, convened at ten-fifteen o'clock, Mr. E. N. Cory, Chairman, presiding, with Mr. E. R. Sasscer acting as Secretary in the absence of Mr. S. B. Fracker.

CHAIRMAN CORY: I would like to announce the appointment of the committees on Nominations and Resolutions.

Nominations: G. M. Bentley, Chairman with Messrs. Cotton and Flint.

Resolutions: W. E. Britton, Chairman, W. C. O'Kane and R. T. Cotton.

It has been customary for the chairman to present a brief address.

ADDRESS OF CHAIRMAN

By ERNEST N. CORY, *College Park, Maryland*

The primary function of the Chairman is to preside over the proceedings of his Section; most of the work is done by the Secretary. We have been most fortunate in having able secretaries in this section, and the present incumbent, in his usual efficient manner, has prepared a program that is replete with interest. Since the topics are mainly specific in their character, I would feel remiss if I did not take a few minutes to point out what seem to me to be outstanding needs in developing the quarantine field.

The importance of quarantines from the economic and sociological standpoints is a matter of common knowledge. Their bearing on the future of entomology and vegetable pathology needs to be continually before our minds. Quarantines may support and lend emphasis to the general pest control program or they may bring discredit to the efforts of

entomologists and pathologists and jeopardize future support for essential work.

Four fundamental needs occur to me that I expect to put before you in outline form with the suggestion that you give your best attention to these needs and in the hope that the ideas presented may lead to full investigation and discussion at some future time when details may be worked out satisfactorily to all concerned.

1. As a basis for future quarantines there is need for adequate exotic pest, reconnaisance surveys, by crops. To meet this need, there should be built up in this country a force of indefatigable collectors, thoroughly trained in survey methods and familiarized with foreign pests by sojourns abroad. This force should operate in cooperation with the states. They should supervise scouting, trapping, and rearing all of those pests that are quite likely to escape the attention of the working entomologists whose time and thought are concerned with the control of endemic pests. Regional laboratories, probably in connection with educational institutions, should receive the collected material and have it determined just as soon as suitable stages for determination can be reared. This ought to be a definitely recognized service, supported and coordinated by the Plant Quarantine and Control Administration, but probably definitely assigned to the bureaus concerned.

2. There should be a special force of competent investigators working under the appropriate bureau heads to complete as rapidly as possible those investigations dealing with methods to enable the public and commercial interests to meet the requirements of quarantine regulations with the minimum interruption and loss. This force should furnish service for the Plant Quarantine and Control Administration under funds allotted by that organization for these specific researches.

3. An information bureau should be set up under some central organization that would enable the dissemination of timely, complete and trustworthy information in regard to quarantine regulations and methods designed to meet the requirements of the regulations. In some cases untrustworthy information may, under the present system, reach the public, growers and shippers. Correction of this possibility, with the view of having necessary quarantine regulations supported by well-informed public sentiment, should be the primary aim in this movement.

4. Further clarification is needed of states rights with respect to their police powers in the control of actually or potentially infested and infected material having the status of interstate shipments.

These ideas are not exclusive in any sense and do not take into consideration the promulgation of the definite set of quarantine principles

that experience shows is so badly needed. These suggestions are not meant as criticisms of present practices, but are offered in the hope that they may help to solve some difficulties that seem to loom on the horizon.

We will now pass to the rest of the program. The first paper is by Mr. Strong. He needs no introduction.

REVIEW OF THE WORK OF THE PLANT QUARANTINE AND CONTROL ADMINISTRATION FOR THE PAST YEAR

By LEE A. STRONG, *Chief, Plant Quarantine and Control Aministration*

At the Des Moines meetings of the Association last year, it was reported to the Section on Plant Quarantine and Inspection that there was before Congress an estimate of $15,381,000, for work on Mediterranean fruit fly in Florida. On account of conditions found, by inspection, to exist in Florida, recommendation was made to Congress by the President on March 20, 1930, that instead of the $15,381,000 requested for the period December 15, 1929, to July 1, 1930, there be appropriated $6,902,404 to carry on the fruit fly work from March 20 to November 30, 1930. Of this amount $1,500,000, was to be set up as an emergency reserve to be used only in case an unforeseen exigency should arise. With the passage of the regular Appropriation Bill for the fiscal year 1931, however, instead of the amount above estimated, there was made available for the Mediterranean fruit fly work in Florida $1,740,000.; and in addition, there was authorized the use of $1,500,000 to be used when the President of the United States decided that infestations of sufficient number and intensity were found in Florida to justify its expenditure. It may be said here that so effective has the work been since its inception that on November 15, 1930, the last remaining restriction on the movement of Florida products on account of the Mediterranean fruit fly was removed. From the placing of the first quarantine by the Federal Government on May 1, 1929, modifications have been made as often as conditions have warranted. It was anticipated that in the spring of 1930 numerous infestations of the fruit fly would be found and that much more intensive eradication work would be necessary than proved to be the case, in view of the greatly improved conditions. It was for this reason and in order to be able to take care of any emergency which might arise that the request for a large appropriation was made to Congress.

In order to have available the best possible advice on the fruit fly work in Florida, the Secretary of Agriculture on January 9, 1930, appointed a

Federal Fruit Fly Board. These men were W. C. O'Kane, Chairman, and George A. Dean, W. P. Flint, P. J. Parrott, and J. J. Davis, members of the Board. Wilmon Newell, who had been the Executive Officer in charge of the eradication work from the beginning of Federal participation, remained as Executive Officer. He continued in this position until practically all activities were suspended by reason of lack of funds in March, when he resigned to devote his entire time to his state activities. W. C. O'Kane, Chairman of the Federal Fruit Fly Board, was then placed in charge of the Federal quarantine activities in Florida. He continued in that capacity until October 15, when P. A. Hoidale, who for some three years had been in charge of the Mexican fruit fly eradication work in Texas, was transferred to Florida and placed in charge of the Mediterranean fruit fly work.

On account of lack of funds, surveys were not made in the southern states outside of Florida to determine the possibility of existing infestation. It would be extremely advisable for the quarantine authorities in these southern states to make surveys during the next fruit-growing season in order that any incipient infestations may be early detected and stamped out.

In the gipsy moth work defoliation was not as heavy during the present year as was the case during 1929. In the barrier zone, in the western part of New England and eastern New York, some 120 infestations were found. In December, 1929, the gipsy moth was found on trees growing in nursery grounds at North Roslyn, Long Island. Investigation showed that this infestation was serious and covered quite an extensive area. Some 4,416 egg clusters were located and treated before the first of March, 1930. With one exception, all of these egg clusters were found within an area of less than two miles from the center of infestation in North Roslyn. The Conservation Department of the State of New York threw into the eradication effort in Long Island all the resources at its command. The work, as is the case with all gipsy moth work, was on a cooperative basis with the Plant Quarantine and Control Administration. The New Jersey situation, which will be more fully discussed by Mr. Burgess, looks most promising.

The brown-tail moth has not spread west of the present quarantine line but more extensive defoliation has been caused by the insect, particularly in southern New Hampshire and in southeastern Maine, than has been the case in recent years.

There has been some spread of the satin moth, and in the spring of 1930 heavy defoliation of poplar and willow trees resulted.

Since Mr. Worthley and Mr. Brewer are to discuss the corn borer question, this will not be touched upon here.

In the spring of 1930, the Japanese beetle quarantine was revised to include in the generally infested area, Harford and Baltimore Counties, the city of Baltimore, and portions of Cecil, Howard and Anne Arundel Counties in Maryland; part of Cedar Creek hundred in Delaware; York County, and portions of Adams, Perry, Lycoming and Lackawanna Counties in Pennsylvania; and Orange and Putnam Counties, and portions of Westchester and Dutchess Counties in New York. A lightly infested area was created, including the District of Columbia and two immediately adjacent counties in Virginia; the remaining portion of Maryland except the extreme northwestern and southern sections of the State; a small section in southern Delaware; fairly large areas immediately west and north of the generally infested area in Pennsylvania; Dutchess County, except the town of Fishkill, and small sections in Ulster and Broome Counties in New York; the entire remaining portion of Connecticut; and Hampden County in Massachusetts. Effective November 10 the quarantine was revised to bring within the generally infested area the District of Columbia, Arlington County and the city of Alexandria, Virginia, and a few townships in Connecticut and Pennsylvania. The lightly infested area was extended to include additional territory in Pennsylvania, Delaware, Massachusetts, Virginia, and to cover the whole state of Rhode Island.

During the fiscal year ending June 30, 1930, there were certified for movement out of the Japanese beetle infested area, 97,788,480 plants. In addition to these, large numbers of cut flowers and carloads of sand, soil, etc., were certified out. Trapping work was continued as an adjunct to the scouting work. There is nothing yet to show that the trap is much more than an indicator of Japanese beetle population.

The pink bollworm was discovered over a large area in the Salt River Valley, Arizona, in October, 1929. Some 47,000 acres of cotton were involved in the infested area and in the protective zone placed around the non-cotton zone which was established by the State early in 1930. Congress appropriated $587,500 with which to clean up the cotton fields in the regulated area. On account of certain conditions which the State of Arizona had to meet, it was not possible to authorize the use of any of this money until February 24. Most effective work was done, however, in cleaning up the fields after this, and maintenance of the non-cotton zone through the season was effective.

One of the outstanding developments in the pink bollworm inspection work has been the building of a machine for the purpose of separating

pink bollworms from gin trash. It has long been recognized that pink bollworms, if present at all in any locality, are more likely to be shown up in gin trash than in any other way. This machine, developed by R. E. McDonald of the Plant Quarantine and Control Administration, and G. J. Scholl of the Texas Department of Agriculture, has been responsible for discovering infestations outside the non-cotton zone which would probably not have been discovered through the ordinary inspection methods.

There has been no material change in the Thurberia weevil situation.

During the past year, there has been no infestation of Mexican fruit fly in the Lower Rio Grande Valley of Texas. During the year some 1,500 alternate host fruit trees of the fly were destroyed voluntarily by their owners in the Valley. There have been voluntarily destroyed up to this time a total of some 39,000 of these trees. Infestation is continually being found just across the Rio Grande River in Matamoros, Mexico; and the bringing up of infested fruits from the interior of Mexico to the Mexican towns just across the line presents a constant menace to the fruit cultures on the American side. They are a constant source of reinfestation and with the increasing bearing acreage in Texas, the Mexican fruit fly problem in that State is getting larger each year.

The date scale eradication work in California and Arizona is making most favorable progress, and it seems probable that during the next year, part of the area can be declared entirely free of Parlatoria scale.

The more or less wide-spread infestations of the several species of bulb flies and bulb eelworms make it necessary to seriously consider the advisability of continuing the present quarantine on narcissus bulbs. Naturally, the removal of the domestic quarantine would, in all fairness, make it necessary to consider the removal of the foreign quarantine as well.

The phony peach disease, which until early in the year was believed to be confined to the States of Georgia, Mississippi and Alabama, was subsequently found in the States of North and South Carolina, Tennessee, Arkansas, Louisiana, and Texas. The quarantine has not been extended to include these additional States; in fact, it applies only to Georgia and a portion of Alabama.

The transit inspection work has been continued and has more than justified the expenditure by the number of interceptions made. For the fiscal year ending June 30, 1930, 1,114 violations were found. On account of scarcity of funds, only a very few of the many transit points throughout the Middle West have been guarded.

A large number of pests not established in this country have been intercepted during the past year by the Port Inspection Service of the Plant Quarantine and Control Administration. Additions have been made to the inspection force in New York, and several ports where no men have been stationed heretofore are now protected. Some thirty men were added to the force at the various ports along the Mexican border.

The continued development and extension of foreign air transportation lines has materially increased the work of the port inspection service. For the fiscal year ending June 30, 1930, 4,497 airplanes were inspected and 400 interceptions of contraband plant material were made.

A unit designated as the Technological Division has been set up in the Plant Quarantine and Control Administration during the past year. This unit is to provide for technical assistants to advise on matters relating to sterilization and disinfection of plant products and to coordinate the methods used in supervising the disinfection and sterilization of plants and plant products to comply with the requirements of the various Federal plant quarantines. This unit will endeavor to devise ways which will make the commercial application of treatments worked out by the research bureaus of the Department more uniform and more economical. This division will also test on a commercial scale new methods worked out as a result of investigations conducted by research bureaus of the Department.

No new quarantines were placed during the year 1930, and two were removed. The Asiatic beetle quarantine was removed on March 1, 1930, and the Mediterranean fruit fly quarantine was removed effective November 15, 1930.

CHAIRMAN CORY: Mr. Strong's paper is now before you for discussion.

MR. A. F. BURGESS: The statement that Mr. Strong made in connection with the moth situation is correct as far as the information he had goes.

However, since being at the meeting I have received a letter from Mr. McIntyre who is doing the scouting work in the Long Island territory. He reports that up to the time his letter was written—which I think was the last of last week—85 egg clusters have been found. There are considerably more egg clusters than were reported previously.

DR. C. L. MARLATT: Having been associated with this plant quarantine work for some 19 years—(23 or 24 years counting from the beginning of the effort to secure the passage of such legislation) and having had

direction of the work during that period and up to last December, it goes without saying that I am keenly interested in its progress and development.

First of all, I want to say that I have been very much pleased with the statement made by the present leader of plant quarantine and control. I do not need to tell you that I think that work is going on in a way which gives me a great deal of pleasure. Naturally, because of my long connection with it, I am interested in the present-day development and the future. I can conceive of no better men to carry on the work than the men now concerned in its direction, and notably the leader, Mr. Strong.

The subject of cooperation between the Bureau of Entomology and the Plant Quarantine Control Administration in work that may be more or less of a research nature, has been accurately stated by Mr. Strong. In that I fully agree. It carries on a method which has been in vogue practically from the beginning.

Naturally, we in the old Federal Horticultural Board looked to the Research Bureaus of the Department for information on all research subjects. But, as Mr. Strong points out, there may be occasions when these bureaus are not able to give the information which is more or less immediately demanded and which is urgent. In that case we had arranged that we would develop the research, facts and conditions, which was needed for our work in cooperation with the bureaus concerned. That is an old policy.

Incidental to that policy it should be noted that the Plant Quarantine and Control Administration, and its predecessor the Federal Horticultural Board, deserves the credit for some outstanding developments in insect and pest control. I do not need to mention the vacuum fumigation which is now in such wide use, and which came out of this work. Mr. Sasscer and others of the Federal Horticultural Board were responsible for some of those developments.

The most recent application is the remarkable device, which I haven't seen and which I have a great curiosity to see—and I hope to see it in operation soon—, by Mr. McDonald, a separating device. From all accounts it is a wonderful thing. It will prove of tremendous utility. A while back when we were asked to point out the outstanding discovery of the year I noted that as perhaps the outstanding discovery in plant pest control for the year.

That leaves me with just one other thought, namely, that we think of the Department as a great research institution. Personally, I include in that research field, plant quarantine and control administration. This is perhaps an old statement, which I have made on several other oc-

casions, but I look upon the plant quarantine work itself as a big demonstrational experiment, the finding out of whether it is feasible to control pests in a large way and eliminate them.

The distinction between that and the research work of the Bureau is chiefly one of dimension. Plant quarantine attempts to control and to finish off an insect on a national scale. We are attempting to determine the means and the methods for doing it on a small scale for wider application.

Therefore, I look upon the whole department, at least this branch of the department, as in a large sense that of research. It is experiment; it is demonstration.

In that work the Bureau is going to cooperate with the Plant Quarantine Control Administration. We are not going to be jealous of any good work that they do. We are going to accept it and utilize it and aid them in it. But, necessarily, we will continue in our present thoroughly amicable and friendly relationship, making some separation between research and application.

Possibly the results of their research will be continued as it was in my day. Mr. Strong will not care to enter upon a field of publication of the outcome of research. In other words, establishing a research division. However, that is up to him. I am not giving out anything more than just an opinion.

I think that in the past we have realized that research should go out through, and become a part of, the output of the Bureau of Entomology; but under the name of the Federal Plant Quarantine and Control Administration we should keep the publications in line through the one channel. That is merely a matter of adjustment. But, the fact remains that there is this tremendous sympathy and cooperation between the two organizations, which I hope will continue.

MR. VAN BUREN: I would like to comment on what Mr. Burgess said about the gypsy moth on Long Island. I think Mr. Burgess will bear me out when I say that there was only one cluster found in a nursery, and that was an abandoned nursery. The masses that were found—as I understand it from Mr. McIntyre—were practically all in woodland areas where they had not sufficient money to spray quite as extensively as they would have liked to spray last year. I think they have that work well in hand now.

CHAIRMAN CORY: We will pass to the paper by Professor O'Kane.

PROGRESS IN MEDITERRANEAN FRUIT FLY ERADICATION

By W. C. O'KANE, *Durham, N. H.*

(Withdrawn from publication)

CHAIRMAN CORY: This very excellent summary of the efficient way in which the job was done is now open for discussion.

MR. L. A. STRONG: The Department appreciates sincerely the work that was accomplished by the Federal Fruit Fly Board. They went to Florida at a sacrifice to themselves and did what has proven to be a mighty fine piece of work.

Another point that needs to be emphasized is that while the laboratory experiments may have proved that the bait spray was 55 per cent efficient, I think that was for one application; that the continued application of the bait must have been pretty close to 100 per cent because the adult flies were certainly all killed.

Another point is that not only were the quarantine regulations modified, as conditions warranted, in 1930, but from the placing of the first quarantine as fast as conditions were found to warrant modifications, the modifications were made.

The men who started the work had nothing at all to guide them. It was an entirely new problem, and one that was looked upon at that time as the worst possible place for the eradication of the fruit fly. They went in there with the ruthless way that was necessary to accomplish the results.

We can look back now and see, perhaps, where certain things that were done wouldn't have had to be done, that certain things might have been overlooked; but we are looking back with experience to guide and they had no guide at all.

I think everybody who had anything to do with the fruit fly eradication program certainly is deserving of every credit.

DR. C. L. MARLATT: A further word along the line of bait spraying. The efficiency of bait spraying was fairly well demonstrated at the very beginning of operations in orchards where the fly was present at the rate of several hundreds to a tree.

The population was determined by dusting the trees with a volatile poison, hydrocyanic acid dust, and a tarpaulin under the tree caught as many as five or six hundred flies. That was characteristic of the first application. After the application of the bait spray corresponding trees were again dusted one day after the application, but instead of five or six hundred flies we got 75. I am giving you these figures from memory.

My recollection is that on the third day after the original spray they got practically no flies, showing a very high efficiency in the beginning. That is important to show the efficiency of bait spraying. New flies were coming out of the ground and the bait spray was perhaps carried off by rain. Certainly that was the case during the rainy season.

We felt then—and I think the facts bear us out—that the bait element of eradication was effective. We believed then that the last fly could possibly be gotten by bait spraying. I think we were wrong. I think the last fly will be taken by the natural hazards that come to fly life. When the fly population gets down low the hazards have a very important bearing.

CHAIRMAN CORY: We will pass to the next paper by Mr. Worthley and Mr. Brewer. Mr. Brewer will present the paper.

THE EUROPEAN CORN BORER SITUATION IN THE UNITED STATES AT THE CLOSE OF 1930

By L. H. WORTHLEY and E. G. BREWER

ABSTRACT

The European corn borer (*Pyrausta nubilalis*) situation in the United States for 1930 has been a most unfavorable season for the borer. Only 61 newly infested townships were discovered in the one-generation area, and 59 in the two-generation area.

In the one-generation area 11,506,154 vehicles were inspected, 279,152 ears of corn were intercepted, and 375 borers were found. In the two-generation area 3,997,735 vehicles were inspected, 60,028 ears of corn were intercepted, and 1,297 borers were found.

There were no heavy losses in the Great Lakes section this season due to corn borer damage.

Decreases in borer population, compared to 1929, of 21 per cent in Michigan, 58 per cent in Ohio, and 29 per cent in Pennsylvania, were indicated; and increases of 35 per cent in Indiana, and 11 per cent in New York were shown.

Losses in sweet corn, as well as to susceptible vegetables and flowering plants, occurred in the most heavily infested portions of southern Massachusetts and Rhode Island.

In discussing the general European corn borer situation in the United States for 1930, it might be summed up briefly by saying that it was on the whole a most unfavorable season for the borer. No great amount of spread took place and no alarming outbreaks productive of serious commercial damage occurred during the year.

SPREAD DURING 1930. The spread of infestation as ascertained by the scouting operations during 1930 was very limited, particularly

in the one-generation area. There were only 61 townships where first records of infestation were made in the one-generation area this season. In the two-generation area 59 townships were found to have newly discovered infestation.

We have always referred in the past to the approximate average width in miles of newly discovered territory. This seems rather impractical this year in view of the fact that there are so many sections where no new infestations were found beyond the line of 1929. In Pennsylvania, along the entire border from Northampton County to the West Virginia State line, no new townships were discovered. This is also true of a considerable area in south-western Ohio and in sections of Indiana.

There were, however, more isolated infestations discovered this past year than ever before. One of these occurred at Calais, Maine, in the two-generation area. There were three in Ohio and three in Kentucky in the one-generation area. It is interesting to note, however, that five of these occurred either in the bottom lands or on islands in the Ohio River. This can hardly be overlooked as indicative of the danger of spread of this injurious pest by the "Water Route," so to speak. Should this agency be responsible for the establishment of undiscovered infestations at some considerable distances from the present known infested areas and then the natural spread by moth flight follow its normal course with the prevailing winds, large areas of the interior of the corn belt might become infested much sooner than otherwise anticipated.

With these facts in mind, it was intended to make a most complete survey and study of river spread, particularly as pertaining to the Ohio River and its tributaries during the past year. This, however, was not possible on account of the condition of the rivers due to drought.

The customary practice has been followed of carrying on scouting operations along the Ohio River and also in eastern areas of Illinois and Wisconsin, in addition to those areas adjacent to the known infested areas.

QUARANTINE. The operation of quarantine No. 43 on account of the European corn borer the past year has been along the same line as previously; that is, the maintaining of vehicle inspection stations, inspection of dining car service and steamship lines during the sweet corn season, and market and field inspection of crops other than corn. The operation of shelled corn inspection service, however, was discontinued August 20, 1930, after a thorough discussion resulting in the belief that

the results obtained by the service did not warrant the expenditures which it involved. The amendment to the quarantine, effective August 20, 1930, removed the restrictions on the interstate shipment of oat and rye straw, celery, and cut flowers or entire plants of cosmos, zinnia, or hollyhock, from the two-generation area of eastern New England. The requirement of certification of cleaned shelled corn and the cleaned seed of broomcorn, sorghums, and Sudan grass was also discontinued as to both the one-generation and two-generation areas. Several years' experience with restrictions on these plants and plant products indicates that infestation in them is so rare that their movement can hardly be considered to involve danger of spreading the European corn borer.

SUMMARY OF VEHICLE INSPECTION DATA

One-Generation Area

	Number Stations	Vehicles Inspected	Ears of Corn Taken	Corn Borers Recovered
West Virginia	16	415,089	4,571	1
Ohio	35	1,075,328	47,117	63
Indiana	45	1,558,079	93,847	279
Michigan-Wisconsin Line	13	387,214	4,571	0
Lake Michigan Ferries*	20	5,702	612	0
Total	129	3,441,412	150,718	343
*(Not full time stations)				
Connecticut	4	11,824	3,814	0
New York	7	473,420	5,072½	2
New Jersey	32	6,380,147	85,058	7
Pennsylvania	23	1,199,351	34,490	23
Total	66	8,064,742	128,434½	32

Two-Generation Area

Connecticut	35	3,452,939	39,695	720
Massachusetts	4	544,796	20,333	577
Total	39	3,997,735	60,028	1,297
Grand Total	234	15,503,889	339,180½	1,672

FIELD CONTROL. The actual work of controlling the European corn borer is very largely operated by the States where such work is being done. In the two-generation area, the States of Maine, Massachusetts, Rhode Island, and Connecticut have compulsory cleanup laws, and cleanup campaigns are conducted each year. The methods prescribed are largely low-cutting of stalks, deep Fall plowing, and burning of debris in general. Several isolated infestations have, however, been cleaned up by the Plant Quarantine and Control Administration, United States Department of Agriculture, and in practically all cases no

infestation was found the following year. For several years cleanup work in Brooklyn and Staten Island has been carried on by the Plant Quarantine and Control Administration, and a very substantial reduction in infestation has been the result.

The demonstration of control machinery which is an important feature of control of the European corn borer has been carried on more extensively the past year. A demonstration farm for the purpose of concentrating at one point along the Atlantic seaboard the several forces engaged in European corn borer investigations and control has been acquired at Berkley, Massachusetts. Although this was contracted for in December 1929, no field work could be accomplished until this spring. It is operated cooperatively by the three bureaus of the United States Department of Agriculture: Plant Quarantine and Control Administration, Bureau of Entomology, and the Bureau of Public Roads. Due to climatic influences, the presence of host weeds and the limitations imposed by prevailing cultivating methods, the infestation in this area has been consistently heavy and further demonstration of control practices is necessary to maintain economic stability of the area.

The farm is amply provided with ledges, boulders, ill drained spots, stone wall fences, and brush areas to exempt it from a classification outside of a typical and average eastern farm. The farm is utilized for the purpose of demonstrating control methods, as a field center, for exhibition of special implements and apparatus, the testing of new control machinery, for the study of larval survival and flight habits as well as the control of the European corn borer on plants other than corn, and for tests in connection with bait traps and insecticides.

The demonstration farm located outside of Toledo, Ohio, was operated this year for its third successive year. This farm is also operated on a cooperative basis between the Plant Quarantine and Control Administration, the Bureau of Entomology, and the Bureau of Public Roads. Unseasonable conditions this year imposed a great handicap on the results obtained from experiments and tests, but a great amount of good was obtained from demonstrations and field training of employees for scouting operations.

STATUS OF INFESTATION AND CROP LOSS. In the Great Lakes section with very few exceptions there were no heavy losses due to corn borer damage in 1930.

The infestation survey of the 1930 corn crop summarized reveals that there has been an average reduction based upon samples examined of approximately 25 per cent in borer population compared to 1929 throughout the areas surveyed in New York, Pennsylvania, Ohio,

Michigan, and Indiana. Decreases of approximately 21 per cent for Michigan, 58 per cent for Ohio, and 29 per cent for Pennsylvania were indicated. Increases of approximately 33 per cent and 11 per cent were indicated for Indiana and New York respectively.

These percentages are given when taking the state as a whole, but the data secured is based upon the county as a unit. In the states showing decrease it should be explained that there are counties where noteworthy increases occurred, particularly in Defiance, Henry, and Williams Counties in Ohio; Lenawee, Macomb, and Oakland Counties in Michigan.

Undoubtedly the first and most important question arising when increases or decreases in abundance of a pest is discussed, is as to the reason. This can best be accounted for by explaining that from the standpoint of weather conditions, the season in general has been one of contradictions and completely abnormal from both the environmental and biological aspects.

In the New England section (two-generation) important losses from the corn borer occurred to sweet corn in the more heavily infested portions of southern Massachusetts and in Rhode Island, as well as to susceptible vegetables and commercially grown flowering plants.

COMPARISON OF BORER POPULATION ONE-GENERATION AREA 1929–1930

	Average Number Borers per 100 plants		Per cent change over 1929	
	1929	1930	Increase	Decrease
Michigan	15.68	12.41	—	21
Indiana	.57	.76	33	—
Ohio	12.89	5.40	—	58
Pennsylvania	.96	.68	—	29
New York	9.21	10.23	11	—

COMPARISON OF BORER POPULATION, 1929–1930, NEW ENGLAND AREA

	Average No. of Borers per 100 plants		Per cent change over 1929	
	1929	1930	Increase	Decerase
Connecticut	8.66	4.43	—	49
Maine	2.56	.01	—	99
Massachusetts	235.61	135.16	—	43
New Hampshire	11.74	1.43	—	88
Rhode Island	187.36	42.10	—	78
Long Island—One-generation	2.35	.54	—	77
Long Island—Two-generation	49.39	34.67	—	30

In general it can be said that the weather features for the New England area were unfavorable for a portion of the season, although not so unfavorable as in the Great Lakes section.

STATUS OF RESEARCH ACTIVITIES. All projects relating to mechanical control, cultural practices, behavior, general and special biology, physi-

ology, chemotropism, parasites, insecticides, host plants, etc., have made encouraging progress during 1930. All results obtained continue to emphasize that clean cultural practices leading to the farm disposal of infested plant material is a most effective practical means of reducing the abundance of the borer and restricting commercial losses from its activities.

There were approximately 750,000 imported parasites liberated at various points in the corn borer infested areas during 1930. In restricted localities, near liberation points, extensive collections of corn borer larvae have demonstrated that these imported parasites were becoming sufficiently numerous to destroy from 6 per cent to 16 per cent of the borers.

There are 19 species of these parasites which have been liberated in the United States since the initiation of this project in 1919. Twelve of these have been recovered under circumstances indicating their permanent establishment.

CHAIRMAN CORY: We will pass to the paper by Mr. L. S. McLaine of the Entomological Branch of the Department of Agriculture of Ottawa and by Lawson Caesar of Ontario. Mr. McLaine will present the paper.

MR. L. S. MCLAINE: In presenting this paper I would like to say that I do so with a great deal of hesitation in view of the fact that it represents the work that has been carried on largely by Professor Caesar as Provincial Entomologist for Ontario. I would also like to say that we have modified the title slightly, in that it is more of a review of the corn borer situation in Ontario from the time of its discovery until the present time.

A REVIEW OF THE EUROPEAN CORN BORER OUTBREAK IN ONTARIO

By LAWSON CAESAR, *Ontario Agricultural College, Guelph*, and LEONARD S. MCLAINE, *Ottawa, Canada*

ABSTRACT

The European corn borer (*Pyrausta nubilalis*) was discovered in Ontario in 1920, it increased in numbers with remarkable rapidity in the main corn growing counties. By 1926 all corn within an area of twelve hundred square miles was devastated. The normal acreage in two counties dropped from 140,000 to 45,000 acres. In the fall of the same year compulsory clean-up was started and has been continued ever since. As a result of the clean-up each spring there has been a reduction in the infestation, there is an increase in the acreage sown to corn, and the farmers feel that they can again grow corn and escape extensive damage.

More than ten years have elapsed since the discovery of the European corn borer in Canada. In 1920, the first infestation of this insect was

found in Welland county, Ontario, and as a result of scouting carried on that season, thirty-five townships covering approximately 2,780 square miles were found infested. (1)[1] Since that time the insect has continued to spread over the province of Ontario at the rate of about forty miles a year and by 1926 could be found in almost every corn growing county. Today, it is present to at least some extent in almost every corn field in that portion of the province east of the Sault Ste. Marie, although many counties are still only lightly infested and are suffering no loss.

The question of controlling the artificial spread of this insect was considered immediately after its discovery, and quarantines were established by the Canada Department of Agriculture which prohibited the movement of corn and its products from infested to non-infested districts. These quarantines were amended as often as necessity arose, by adding to the quarantined areas any newly infested territory. With regard to the actual control of the insect on infested farms, strenuous efforts were made each year to secure the cooperation of the individual farmer by having him destroy the refuse of the corn crop. Both federal and provincial authorities carried on this extension work. It was not, however, until 1925 that a general policy was arrived at by both Federal and Provincial Departments of Agriculture whereby the actual control work was turned over to the province, but the federal Department continued to establish and maintain quarantines to prevent the artificial spread of this insect.

In accordance with the above policy, the Legislative Assembly of the Province of Ontario passed "The Corn Borer Act" in the spring of 1925, but too late in the season for any action to be taken that year. The Act was amended in the spring of 1926. That fall preliminary work was carried on and the following spring compulsory clean-up was put into force. The Act (2) provides for the appointment by a council of a county, city or separated town or upon notice in writing by the Provincial Entomologist, of an inspector for the purpose of controlling the corn borer. The inspector is under the instruction of the Provincial Entomologist, and may adopt only such methods as are approved by the above-named official. Inspectors are empowered to enter any premises where the corn borer is believed to exist and give advice and instruction to the owner or occupant as to the methods to be adopted to control the insect. When the owner or occupant neglects or refuses to carry out such instructions, the inspector may carry out such measures, and any expense so incurred is entered on the collector's roll and collected in the same manner as other taxes. Every person who refuses or neglects to carry out the instructions of or obstructs the inspector may incur a penalty.

[1]The numerals refer to the literature cited in this paper.

The province reimburses the county or municipality to the extent of one-half of the salary and expenses of the inspector. A series of regulations have been passed in accordance with the Act, dealing with the destruction of the crop refuse, ploughing of corn fields, storing of corn, etc.

Up until the fall of 1926, when the Corn Borer Act was brought into effect and clean-up of corn remnants made compulsory, the rate of increase in infested counties varied greatly. Counties which grew corn almost solely for fodder had a much slower rate of increase than counties which grew corn almost solely for husking. The explanation of the difference in the rate of increase was largely as follows. In the husking corn counties, the stalks were not used to any great extent for feed, but were left on the surface of the field over winter. In the spring the field was disced thoroughly and sown to grain without ploughing-under the remnants. This afforded ideal conditions for the borer to survive, for very few were killed either by winter or by the cultivation of the soil. This condition prevailed in Essex and Kent, the two largest corn growing counties not only in Ontario, but in all Canada. The increase in the intensity of infestation in these two counties was spectacular. An exceedingly light infestation was found in three townships in Essex and eight in Kent in 1921. For the first two years the rate of increase was slow but by 1924 commercial damage to the crop was noted in several districts; by 1925 the stalk infestation had risen to 53 per cent in Kent and 38 per cent in Essex and the corn crop over four hundred square miles was almost a total loss. By 1926 (3) the stalk infestation had increased to 79 per cent in Kent and 83 per cent in Essex and the devastated area had increased to twelve hundred square miles. Many fields in both counties had an average of ten to twenty borers per stalk and a few as high as fifty to sixty.

On the other hand, in the counties where corn was grown for fodder the rate of increase during the same period was not more than one-tenth as rapid as that in Essex and Kent. The explanation being that the fodder corn was cut and either ensiled or fed and most of the stubble was ploughed-under before the next crop was sown. These two operations destroyed the great majority of the borers and so retarded the rate of increase.

As has been mentioned previously strenuous efforts had been made to induce farmers generally to adopt control practices and destroy crop remnants. Many responded at first, but when they found that others did not, they said it was useless to continue unless every one was forced to co-operate. To get all to co-operate meant compulsion, and it was not until the great corn area was ruined, and every thoughtful man

could see that something must be done unless corn growing was to be a thing of the past, that the time was really ripe for compulsory measures to be taken. The Corn Borer act which has been mentioned above was put into operation in the fall of 1926 (4). This Act as already stated, makes it possible for any county voluntarily to adopt compulsory control and it also empowers the Provincial Entomologist to put the Act into force in any county, though up to the present time no county has come in voluntarily.

The first year eight counties were brought under the Act, and the following two years (1927 and 1928), sixteen more were added. These form an unbroken line about 300 miles long from east to west and about 35 miles wide from north to south. They include the great mass of the corn growing counties. The principle followed in bringing a county under the Act, is to wait until the borer has become abundant enough to cause considerable damage, i. e. until the corn growers realize that the borer is in their midst and will likely soon become a source of loss.

One head inspector is appointed for each county and where necessary he has one or more assistants. All inspectors are appointed by the County Council, but great care is taken to point out to the various county councils the necessity of appointing only the most suitable men. All inspectors are under the supervision of the Provincial Entomologist. As half the money expended is refunded by the provincial government, the total costs to the counties is only a little in excess of twelve thousand five hundred dollars per year. Each spring before assuming their duties, the inspectors are called into conference. At these meetings anything of value to the work is discussed and they are informed of any new or valuable data either in regard to the life-history or control of the insect. The great mass of the work is done in the spring, but in the fall the inspectors carry on advisory work among the farmers with the object of preventing the latter from making costly mistakes. Each spring as the inspection nears completion, the Provincial Entomologist visits all the counties and checks the work of the inspectors.

It was thought at first, that it would be difficult to secure the co-operation of the farmers, but this has not proved to be the case. The right type of inspector, one who is fair, firm, just and tactful, can secure cooperation and good will. Up to the present time there have not been more than four prosecutions per county per year, and no inspector has ever failed to win his case. The farmers still remember what happened in 1926, and realize that in order to save the corn industry, each and every one must play his part.

The following table shows what has been accomplished in six of the twenty-four counties since the Act has come into force. These counties form a solid block in the southwest portion of the province, and include all the counties most heavily infested at the time the Act was passed:—

TABLE SHOWING THE RESULTS OF THE CORN BORER ACT—PERCENTAGE OF STALKS INFESTED—IN A SOLID BLOCK OF SIX OF THE HEAVIEST INFESTED COUNTIES

County	1926	1927	1928	1929	1930
Essex	83.0*	64.7	41.7	35.9	16.7
Kent	78.7*	48.8	35.0	21.4	22.2
Lambton	34.0*	56.9	21.4	14.2	7.4
Middlesex	28.5*	36.2	18.3	9.9	9.0
Elgin	40.0	37.1	24.0	20.9	9.0
Norfolk	16.6	10.0	19.7	6.1	5.1

NOTE—The year 1926 was the last year previous to the Act. The figures in it marked with an asterisk (*) are federal, the remainder are provincial.

To refer particularly to Essex and Kent where the greatest damage was done, it is of interest to note that the effect of the damage in 1926 was responsible for a reduction in acreage planted in corn, from a normal of about 140,000 acres, to about 45,000 acres in 1927. Moreover, all the corn canning factories were forced to close down. Almost everyone felt that corn growing was doomed. Last fall, 1930, after four years under the Act only about a dozen plots even of very early sweet corn were ruined. The heaviest infested field corn, so far as known, was one of dent, which had about 90 per cent stalk infestation. This field instead of having twenty to fifty borers per stalk, as many had in 1926, had not more than five, and instead of being a total loss gave a fair yield of good ears. Another striking change is that all the canning factories have now re-opened, and though there are some infested ears brought in, they are not enough to seriously interfere with the canning. The acreage sown to corn has increased during the last three years approximately 100 per cent over what it was in 1927, and instead of most of the corn being planted late to escape borer attack, fully 90 per cent this year was planted about the normal date. Confidence has returned to the farmers, they feel the borer is beaten, in fact most farmers have now much less fear of the borer than the writers have and therein lies a great danger.

Weather plays such an important part in determining the number of borers, that it has always to be kept in mind in discussing artificial control. There is no doubt that the weather during the past summer, which was very dry and hot in most of the above counties as well as in Ohio and Michigan, was an enormous factor in reducing the number of borers. In some counties it was responsible for a mortality of over 90 per cent, whereas in others where there was a number of showers during

the critical periods, there was a slight increase in spite of a good clean-up. Be this as it may, there is no doubt that the destroying each year by clean-up of 95 per cent of all the previous year's borers by feeding, ensiling, burning or ploughing has had a great influence in bringing about the decrease. Furthermore, in counties where compulsory clean-up has not been in force, the borers have been increasing instead of decreasing, so that although unfavourable climatic conditions have been extremely helpful, it is believed that compulsory clean-up has been chiefly responsible for a reduction in the borer population. It is however realized that in seasons specially favourable for the borer, the best that can be hoped for with the present methods, is to prevent the insect from increasing rapidly.

The most pressing need in Ontario today is to devise simple, inexpensive methods of dealing with corn fields, so that the farmer will not have to spend extra time in hand-picking or cleaning his field in the spring. The low-cutting stationary knife attachment for corn binders seems to be the most promising yet discovered, but it is still doubtful if this will be a success in stony ground or in very weedy, thick corn. Corn stalk shavers are also promising, improved side-delivery rakes have a place, and more attention should be given to choosing the right type of plough and equipping it properly.

As a result of the fairly rapid reduction of the borer in most of the area under the Act, there has come about a dangerous feeling of over confidence which will not be easy to deal with. No one is asking for the repeal of the Act, but many farmers are asking to have the clean-up regulations relaxed, on the ground that the menace is past. Such requests are natural, but for many years to come the only safety for corn growing in Ontario seems to be a good clean-up each season by all the growers in both rural and urban districts.

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Chairman Cory: We will pass to the next paper by A. F. Burgess.

THE ERADICATION OF ISOLATED GIPSY MOTH OUTBREAKS

By A. F. BURGESS, *Melrose Highlands, Mass.*

ABSTRACT

A brief review is given of the methods used in eradicating isolated colonies of the gipsy moth (*Porthetria dispar*), with information concerning a number of infested locations where eradication has been accomplished.

During the period from 1890 to 1900 the Massachusetts Department of Agriculture conducted the most extensive insect extermination campaign that had ever been attempted, the purpose being to exterminate the gipsy moth in an area of over 200 square miles encircling the city of Boston.

A system of inspection known as scouting was used for the purpose of locating infestations prior to the application of clean-up operations. Methods of treatment had to be devised for destroying the insect. The principal ones developed were treating the egg clusters with creosote, cleaning up and destroying by fire badly infested trees and rubbish, banding trees with burlap to furnish artificial hiding places where the larvae could be destroyed, or with sticky bands to prevent the caterpillars from descending the trees, and spraying the foliage for their destruction. Spraying however, was not used extensively until arsenate of lead was discovered to be an effective insecticide by experts employed on that project. The method of its manufacture and the equipment available for spraying were so crude judged by present day standards, that treatment of this type was not extensively used. By the application of these methods however, thousands of colonies of the insect were exterminated. Native natural enemies proved to be a negligible factor in exercising even a small measure of control and no attempt was made to introduce foreign enemies of this pest as the object of the project was to exterminate the insect.

The work was financed entirely by the State of Massachusetts, and a quotation from the annual report of Doctor C. H. Fernald in 1897, after the work had been in progress for seven years, gives evidence of the economic soundness of the project:

"In my report of January 1897, to this committee, I gave an estimate of the time and money that would be required to exterminate this insect which was an appropriation of not less than $200,000 a year for a term of not less than five years, and then an appropriation of not less than $100,000 a year for a term of not less than five years, after which an appropriation of perhaps $15,000 a year for a period of five years would be required.

* * * * * * * * *

There can be no doubt that each taxpayer in the Commonwealth of Massachusetts should be interested in this work, and, in justice to himself, consider whether it is possible for the State to exterminate this insect; and, in this case, whether it will cost him more in taxes than it would to fight the insect himself when it reaches his premises. To determine this question we have only to consider that the value of the taxable property in this State is $2,429,832,966, and an appropriation of $200,000 is a tax of less than one-twelfth of a mill on a dollar. A man having taxable property to the amount of $5,000 will have to pay a tax of only 41 cents and 6 mills for this purpose. If we suppose a man on a $5,000 farm should have to pay this tax annually as long as he carries on the farm, say, forty years, the sum total of his tax during all those years would amount to $16.64, which is far less than it would cost him to clear the gipsy moth from his premises in a single year. Such a farmer in the western part of the State can look upon this tax as a premium paid to the State to protect him from damage by the gipsy moth, in the same way as a premium paid an insurance company protects him from loss by fire. If, however, the Legislature continues to adopt the recommendations of the gipsy moth committee till the pest is exterminated, this tax will continue but a comparatively few years."

The work was conducted three years longer, at which time no further funds were made available by the Legislature. While it is true that the management of the work at times made mistakes, which is typical of most human activities, still the principal reason for discontinuance of the work was due to the fact that no appreciable damage to trees could be observed in the infested area, which indicated to the layman that the pest had disappeared. This attitude was reflected in the final report of the committee of the Massachusetts Legislature, which stated:

"******We find no substantial proof that garden crops or woodlands have suffered serious or lasting injury or are likely, with that precaution or oversight which prudent owners are disposed to give their own interests, to be subjected to that devastation which one would have the right to anticipate from these reports. It appears to us that the fears of the farmers throughout the State have been unnecessarily and unwarrantably aroused, evidently for the purpose of securing the effect of those fears upon the matter of annual appropriations * * * We do not share these exaggerated fears and the prophesies of the devastation and ruin are unwarranted and in the most charitable view are but the fallacies of honest enthusiasts." As a result of the report of this committee no further appropriation was made for carrying on the work.

After the close of the work in 1900, the insect increased enormously and in conjunction with the brown-tail moth, a European tree-defoliating insect which was first found in the same region in 1897, enormous areas of both residential and forest growths were defoliated. The result has been that the work was resumed by the State of Massachusetts in 1906 for the purpose of controlling these pests and continuous work has been done since that time by the States which have been invaded by these insects in order to accomplish partial suppression. Gross expenditures averaging over $1,000,000 annually have been made by the Federal Government, the States concerned, the cities and towns, and thousands of individual property owners.

This background has been given in order that it may be understood that more than 30 years ago the experts who were the best informed on the control of injurious insects had the courage to attempt a task of large proportions which was economically sound but which failed to accomplish its purpose, although it was repeatedly demonstrated that small outbreaks of this insect could be exterminated.

With the passage of time the methods of control have been vastly improved, although for the most part the same type of treatment is applied.

Since the United States Department of Agriculture has been concerned in active field work on the gipsy moth project for the purpose of preventing the spread of this insect to parts of the United States not known to be infested, a considerable number of isolated colonies have been found, some rather near and others hundreds of miles from the area known to be infested, and it has been the duty of the Department in cooperation with the States concerned, to exterminate these outbreaks for the protection of the country at large.

On February 3, 1914, a report was received from a tree surgery company that gipsy moth egg clusters had been found on a large estate where they were working, in Bratenahl, Ohio. This report was immediately investigated and proved to be true. This infestation was found on the estate of Mr. C. A. Bingham, which is located between the Lake Shore Drive and Lake Erie and is about one-half way between Gordon Park and White City, which at that time was an amusement park in the city of Cleveland. The township of Bratenahl covers an area along the lake front approximately two miles long and one-half mile wide and is entirely surrounded by the city of Cleveland.

The tree growth consisted principally of trees ranging from 50 to 85 feet in height and 1 foot to 1–½ feet in diameter, and most of the estate was wooded with this type of growth. Several men were detailed from the gipsy moth scouting force to examine the estate and the territory

surrounding it. Cooperation was secured from the State nursery inspector of Ohio and assistance obtained in cleaning up the infestation. Seven new egg clusters were found on the estate and an area of about a square mile was carefully scouted. This included Gordon Park, Cleveland, on the west and White City Park on the east. In the spring of 1914 the trees at the center of the colony and in the territory surrounding it were banded with burlap and the estate and surroundings sprayed. No gipsy moth larvae were found during the summer. During the fall of 1914 and the spring of 1915, scouting was continued by the Federal force for the purpose of checking up the results of the work.

While this work was in progress it was discovered that several carloads of field stone had been shipped from Massachusetts to an adjoining estate. This stone had been taken from a badly infested locality and egg clusters were present on it, many of which were broken. It had been used for building a wall on the estate. This shipment was not made in violation of the Plant Quarantine Act because at that time this act provided for the regulation of shipments of plants and plant products only.

As a result of this shipment regulations drawn by the Bureau of Entomology were approved by the Secretary of Agriculture, making it necessary for stone and quarry products moved from the area infested with the gipsy moth subject to inspection and certification. The following year the Plant Quarantine Act was amended to cover material of this type.

Because of this shipment additional scouting was carried on and in the spring the spraying program was enlarged. Trees along the roadways from the point where the freight cars were unloaded to the estate were thoroughly sprayed under the supervision of the Federal gipsy moth force, the State of Ohio furnishing the spraying equipment, supplies and labor. As a precautionary measure the territory was again sprayed in the early summer of 1915 by the State nursery inspector. During the fiscal year 1916 and 1917 these estates and the surrounding territory were carefully scouted but no evidence of the gipsy moth was found. The work was checked up in 1918, 1919 and 1920; no evidence of the gipsy moth was discovered and it was considered that the pest had been exterminated.

This case is cited, first, because this infestation was farthest west from the gipsy moth infested area and also to emphasize what would have resulted in Ohio and other central States by this time if prompt and effective exterminative measures had not been applied.

During the same year, 1914, another vigorous colony was found at North Castle, Westchester County, New York, some 30 miles north of New York City. Experienced men from the Federal gipsy moth force were detailed to treat the egg clusters, and in addition, several experienced scouts were transferred to that area to assist in stamping out this colony. The principal infestation occurred on a large estate and the caterpillars began hatching soon after the egg clusters were found. A considerable area was scouted around the infestations and egg clusters and caterpillars were found over an area of about three-quarters of a square mile. Many of the trees were growing on rough rocky soil, so that it was very difficult to do thorough work. About 15,000 egg clusters were treated during the month of May 1914. The Federal scouts examined considerable territory around the borders of the original infestation and several additional scattered egg clusters were found. Conditions were such that thorough scouting could not be done as the egg clusters had hatched but in spite of this handicap good results were obtained.

About 6,000 tanglefoot bands were applied to the trees in this locality and in the area beyond the tanglefoot bands about 4,000 burlap bands were applied to the trees to determine, if possible, whether caterpillars were present outside of the known area. Thorough spraying was carried on using a State of New York sprayer, and at the close of the fiscal year 1914 the number of caterpillars located on the tanglefoot and burlap bands was small.

In November 1914, a crew of Federal employees were detailed to work at this infestation. Intensive cleaning work was done in order to locate any egg clusters which might be present. This work was continued throughout the entire area where caterpillars were found during the previous season, 7 egg clusters being located in the original infested locality during the fiscal year 1915. Intensive work disclosed two other infestations about 1,000 feet from the original site. Woodland examined on the opposite side of the State road from the colony resulted in finding another colony. On completion of scouting the work was taken up by the New York State authorities, that is, the labor was paid from New York funds, the work being supervised by employees of the Federal gipsy moth force. General thinning operations were carried on where woodland infestations were discovered. An additional power sprayer was secured and the area was sprayed three times during the spring of 1915. Over 100 miles of roadways and 2500 acres of woodland were carefully scouted.

This work was continued during the fiscal year 1916 and resulted in the finding of 8 egg clusters, all of which were located outside of the area which had been sprayed. The entire area which had been previously found infested was reexamined very thoroughly but no infestation was found. Intensive spraying work was conducted during the early summer. During the fiscal year 1917, the infested area was scouted very thoroughly and although no new egg clusters were located, a limited amount of spraying was carried on as a precautionary measure. The area was examined during the fiscal years 1918, 1919, and 1920, but no infestation was found and it was considered upon completion of this work that the infestation had been exterminated. During the fiscal year 1927 the Conservation Department of the State of New York scouted Westchester County. Special attention was paid to the territory at North Castle but no infestation was discovered. This confirmed the conclusions reached in 1920.

Some of the isolated gipsy moth infestations which have been exterminated are listed below:

Place	Year found	Location	Extent of area infested Acres	Gross area scouted and treated Acres	Year extermination completed
Geneva, N. Y.	1912	Open, level, sparsely wooded country near a nursery	50	3840	1919
Rutherford, N. J.	1914	In small coniferous growth. A nursery plantation	3	2560	1920
Brooklyn, N. Y.	1920	In and adjoining Prospect Park. Thickly settled section	100	5760	1924
Loretto, Pa.	1920	In ornamental stock on private estate	2	10240	1922
Greenport, L. I., N. Y.	1921	In village—shade and fruit trees. Nearly sea level	300	30080	1926
New Haven, Conn.	1924	Shade and shrubbery—thickly settled section of city	5	14260	1929
Alburg, Vt.	1924	Woodland and pasture level—Champlain Valley	200	30080	1927
Bennington, Vt.	1924	Woodland and apple trees—mountainous—high elevation	10	23040	1929
Castleton, Vt.	1924	Woodland—hilly country	50	22400	1927
Danby, Vt.	1924	Woodland and pasture—high elevation in mountainous country	250	39900	1929

Place	Year found	Location	Extent of area infested Acres	Gross area scouted and treated Acres	Year extermination completed
Essex, Vt.	1924	Woodland and open in rolling country—rock and ledges	1000	55140	1929
Fairfield, Vt.	1924	Woodland and fruit trees. Rugged country—high elevation	25	25600	1929
Fair Haven, Vt.	1924	Woodland, hilly ledges.	125	25600	1928
Ferrisburg, Vt.	1924	Shade, fruit, pasture, woodland, flat country — in Champlain Valley	500	51200	1929
Salisbury, Vt.	1924	Woodland in rugged country	60	16640	1927
Benson, Vt.	1925	Fruit, shade and woodland. Level to rolling country	25	25600	1928
Chesterfield, N. Y.	1925	Woodland in mountainous very ledgy country bordering Adirondack Mt. Region	100	45440	1927
Leicester, Vt.	1925	Woodland along lake shore, a summer resort	50	11520	1927
Moriah, N. Y.	1925	Woodland—old apple trees, mountainous region bordering Adirondack section	50	39040	1927
Greenwich, Conn.	[1926	Brush, stone piles, rubbish, rolling country, settled district	100	12800	1929
Ira, Vt.	1927	Orchard and woodland in hilly country	30	10880	1929
Pittsford, Vt.	1927	Scrub growth and shade trees in pasture—rolling country	7	26240	1929
Rutland, Vt.	1927	Woodland and pasture, high elevation	300	15360	1929
Seymour, Ct.	1927	Woodland and pasture in rolling country	20	9509	1930
Woodbridge, Ct.	1927	Woodland in rolling country	12	12758	1930

In addition to the infested points listed above, hundreds of other isolated gipsy moth infestations have been exterminated by Federal and State forces working independently or cooperatively.

The largest eradication project on the gipsy moth in territory outside the New England area has been carried on in New Jersey centering around the City of Somerville. Progress on this project has been reported at various times but brief mention can properly be made at this time. More than 400 square miles was originally infested which, if figured on the basis of town boundaries, increased the area to 924 square miles. In addition to this, intensive inspection and scouting work was necessary in a wide belt surrounding this area which necessitated during

the progress of the work the scouting and careful cleanup of 2369 square miles. In 1921, the first year intensive work was done in this area, over 3,000,000 egg clusters were treated. Since May 1, 1929, no infestation has been found. There still remains about 100 square miles where intensive scouting will be required but rapid progress is being made in completing this project. Throughout the time this work has been in progress the most hearty cooperation has existed between the Federal force and the Department of Agriculture of New Jersey, and the expense of operations has been mutually shared.

Methods of treating gipsy moth infestations have been continually improved. Marked progress has been made in the development of more effective spraying equipment, and the use of fish oil as an adhesive with arsenate of lead spray has increased the effectiveness of spraying and reduced the cost.

The major cost of extermination, however, is not covered by the expense of treatment. Scouting and reinspection of the territory is necessary and this must be accompanied by continued check-up work after the last surviving insect has been destroyed. This work is tedious and requires thorough organization, effective management and loyal men who believe in the value of the project, who are able to overcome difficulties and who have faith that results can be accomplished. Ample funds must be available to carry through to completion an extermination project. The expense is considerable but if the figures quoted from the report of Prof. C. H. Fernald are applied to the accomplishments on the gipsy moth project in the outlying infestations above cited, rich dividends have already been paid.

In every outlying infested location where extermination of the gipsy moth has been attempted the results have been successful.

Since 1913, in addition to the above activities, a Federal inspection service has been maintained which has prevented the spread of the gipsy moth and the brown-tail moth to distant points and since 1923, in cooperation with the Conservation Department of the State of New York, systematic scouting and clean-up work in the barrier zone directly east of the Hudson River has effectively prevented local spread of the gipsy moth to the west.

...The morning session adjourned at twelve-thirty o'clock...

Tuesday Afternoon Session, December 30, 1930

The meeting convened at two o'clock, Chairman Cory presiding.

CHAIRMAN CORY: We have with us Dr. Fisher of the United States Department of Agriculture who will speak to us on Arsenical Residues.

RECENT DEVELOPMENTS IN SPRAY RESIDUE REMOVAL

By D. F. FISHER, *Principal Horticulturist, U. S. Bureau of Plant Industry, Office of Horticultural Crops and Diseases*

It is presumed that what is desired from a horticulturist in discussing this subject is a frank statement from the horticultural viewpoint. Your investigations on the practicability of modifying existing spraying practices and on possible substitutes for arsenical sprays, must be hinged—to some extent—upon the progress being made in the development and application of methods for removing arsenical residues from fruit.

The progressive lowering of the tolerance for arsenic permitted on apples moving in interstate commerce and the rigid adherence to a low tolerance on apples for export has brought an increasing number of producing areas face to face with the problem each year. To some degree also it has made it increasingly difficult in all areas to satisfactorily condition fruit which does not yield to ordinary methods of residue removal. These difficulties probably can be expected to continue in different parts of the country and to vary in degree from season to season.

This prospect involves two kinds of difficulties: (1) what may be termed psychological difficulties, those involved in familiarizing growers with the necessity of removing arsenical residues and with methods therefor without disorganizing marketing operations, and (2) technical difficulties in connection with fruit cleaning methods.

Viewing the problem in a broad light, after passing through the fiery upheaval which has attended its introduction into various parts of the country, one comes to the conclusion that the psychological aspects of spray residue removal, rather than attendant technical difficulties are the factors which need greatest emphasis at the present time. Effective methods of removing arsenical residue by washing the fruit with various chemical solvents have been developed and put into commercial practice with generally satisfactory results. But the growth of understanding and appreciation of the problem and the dissemination of existing knowledge concerning it have been slow.

Until this last season this responsibility was left, for the most part, to those personally concerned in investigational or regulatory work dealing with spray residue removal instead of being handled by extension agencies that usually consider this to be their own special province. Indeed, in many localities these agencies have not only avoided the problem but have reflected the short-sighted opposition of

ill-informed local producing and trade interests. Consequently, growers and packers have been slow to equip themselves to do the work, have not been informed concerning methods of procedure nor advised regarding special precautions necessary to avoid damage and loss. During the past season, however, this responsibility developed directly upon extension agencies in many parts of the Middle West and East, since no one else was available to do the work which a strict regulation of shipments made necessary. It therefore appears that the problem has finally been rounded out by the enlistment of all essential agencies whose services the fruit grower has a right to expect in such emergencies—regulatory, investigational and extension or educational.

The extended drouth of the past season brought the spray residue problem into prominence over wide areas of the United States—places where no preparation had been made to clean the fruit. In these areas and in others where borderline residue conditions have been found it would seem to be the part of wisdom to anticipate preparation to clean the fruit, for a progressive reduction of the tolerance and a stricter regulation of shipments will eventually make cleaning necessary. In fact, it appears that the fruit industry at large will not be able to rid itself of the uncertainty and insecurity which spray residue creates every year, until fruit cleaning requirements are accepted and prepared for as a matter of course.

One of the first reactions of fruit growers when confronted with spray residue problems is to curtail the spraying program or to modify it, especially during the latter part of the growing season, in the hope of avoiding the necessity of having to clean the fruit. This frequently results in considerable loss due to an increase of wormy fruit. At the same time it very often happens that excessive amounts of arsenical residue remain from early season applications and the fruit has to be cleaned anyway so that a double disappointment results.

The spray residue problem has also stimulated a fevered demand for substitutes for arsenical sprays. It would unquestionably be desirable to have effective substitutes, particularly if such could be found which leave non-objectionable residues. However, unless these substitutes are in the nature of a repellent or of an ovicide they must be of a poisonous character to combat the worms. It may be anticipated then that if effective in poisoning one form of animal life the same substances may have a similar tendency if included in human food. The problem is not merely how to get away from arsenical residue but how to avoid objectionable residues of whatever nature.

When confronted with the possibility of having to wash their fruit, growers are often prone to try all manner of substitutes for lead arsenate without particular regard for any prior demonstration of their effectiveness. Entomologists and horticulturists as well have a real responsibility under these circumstances to discourage this tendency and to urge growers to retain tried and proven methods of dealing with codling moth until substitute spraying materials and modified spraying schedules have been thoroughly investigated and demonstrated by orchard trial. On their part, fruit growers can well demand a close coordination between the work of entomologists, chemists, and horticulturists dealing with the problem, insisting that no spraying program be recommended which will create an unsolved residue removal problem.

The apple grower must control worms to stay in business. He cannot afford to experiment independently nor to take chances on unproved methods of codling moth control. Spray residue is not such a bug-a-boo as to require extremes of this nature. In the Pacific Northwest where the most experience has been had with the problem, and where at first it probably was more violently opposed than in any other part of the country, opposition and fear have practically disappeared. Packer after packer asserts that he would continue to wash his apples even if all compulsion to do so were removed. They have found that washing properly done does not injure the apples nor impair their keeping quality; that it pays to handle fruit "with a clean bill of health" and to know that it is not going to be seized after shipment and involve greater expense for conditioning than if it were cleaned at once; that the removal of dirt and spray residue improves the appearance so that washed lots are more attractive and command better prices; that a greater per cent of washed fruit can be placed in higher grades because dirt and residue obscure color necessary to these grades; and that sorters do a better job of removing defective fruits because they can recognize them better and also handle more fruit per day when it is washed. Many estimate that the saving in sorting and grading offsets the extra cost of washing so that the other advantages represent clear profit. If these facts, together with available information on methods of removing spray residue could be taken to growers when they are first confronted with the problem, it would smooth the way for them and needless fears, expensive delays and losses might be avoided.

The great bulk of the apple crop can be cleaned easily, safely and simply by washing in dilute hydrochloric acid. The effectiveness of hydrochloric acid can be increased by heating the solution and by the addition of certain neutral salts such as sodium chloride and sodium

sulphate. By using a 1 per cent solution of hydrochloric acid, and adding kerosene emulsion to make a 1 per cent strength, the residues from arsenate-oil spray combinations can be removed, and these have been the hardest to contend with. Alkaline washes, notably trisodium phosphate, borax and sodium carbonate in various mixtures, have also been effective in removing oily residues.

While means and methods of procedure for satisfactory arsenical removal have been developed, it must be admitted that our present progress leaves much to be desired in connection with the corrosive action of the acid solvents on the washing machinery, particularly when heat is used and salt is added. But with present knowledge and demonstrated procedure there need be no misgiving about the possibility of removing excessive arsenical residue from practically any apple crop. Since this is true, growers' interests will be best served if they are urged first of all to control codling moth by whatever spraying program has been found to be most successful under their particular conditions, and then to prepare to remove excessive amounts of spray residue after harvest.

CHAIRMAN CORY: Dr. Fisher has had probably more experience with spray residue removal than any other individual in the United States.

MR. P. J. PARROTT: I am going to ask what we are going to have this next year for fruits for domestic consumption in the way of tolerance? Isn't there a move under way to reduce the tolerance?

DR. D. F. FISHER: It was announced, in the beginning that there might be a progressive reduction in the tolerance, but no change has been announced for next year as yet.

MR. P. J. PARROTT: Do you happen to know what the manufacturers of wiping and washing machines are doing in the way of devising a machine that can be adopted by the smaller orchard owners?

DR. D. F. FISHER: There was a small one with a capacity of four or five hundred bushels a day. I believe that is still on the market. But, the manufacture of commercial washing machines is practically a monopoly because of a recent merger of several companies. I do not know what they are going to do.

MR. P. J. PARROTT: The larger outfits are a little too expensive.

DR. D. F. FISHER: This matter has been worked out in many localities by community packing houses, or community washing machines. Several of the growers have gone in together.

MR. E. W. BERGER: Was anyone ever poisoned from eating apples that had been sprayed with arsenical spray?

DR. D. F. FISHER: I do not have statistics on that matter. We have records of serious illnesses having been produced in England from arsenic on fruit. The Skin and Cancer Clinic, of New York City, I believe has some very interesting and suggestive case records of patients who have come to the clinic. I think there are some pretty authenticated records of injurious effects occasionally.

MR. E. W. BERGER: In the production of cancer, or what?

DR. D. F. FISHER: In serious skin troubles.

MR. E. W. BERGER: Isn't it just as well to lay all of that aside and forget about it, put the process on the basis of the improved finish of the fruit?

DR. D. F. FISHER: I think so. I think that is the way the problem has to be regarded. The laws are here, the regulations are here and they are going to be enforced. There is no question about that.

DR. T. J. HEADLEE: In our own case we meet the small growers' needs with a home-made washer. It is of a very good size. It can be built for about $50 complete. We have put in a great many of them and they are satisfactory. The primary difficulty with all washers is bruising. Even the best washers bruise, particularly as regards the early fruit.

As for growers continuing to wash after they do not have to, I am from Missouri on that proposition. I do not believe all that I hear. We have growers tell us that they will continue to do it but I do not think they will. I think it is just a temporary thing with them. They will wash as long as they have to. The only way to get the growers to wash is to convince them that they have to.

MR. P. J. PARROTT: An interesting development of our work, in New York, has been the fact that the acid treatment hasn't removed the spray residue. In order to get by we have to hook up two different kinds of machines, the acid bath coupled with a wiper or brusher.

DR. D. F. FISHER: You do have a certain amount of residue, but I doubt whether it is arsenical residue.

MR. P. J. PARROTT: The acid bath leaves the fruit dirty because of the fact that we have to combat apple scab in New York, which requires heavy mid-summer treatments sometimes. The acid treatment does not remove the spray residual.

DR. D. F. FISHER: It will take off on the Bordeaux satisfactorily and will remove the arsenic. The sulphur residues are removed better by some of the alkali and mechanical wipers.

MR. E. W. BERGER: I rather disagree a little with Dr. Headlee. I am from Florida, and not from Missouri, but probably the location would make no difference.

There is probably very little citrus fruit sent out of the state of Florida today that is not washed. I do not remember that there ever was a law passed that required the growers to wash their fruits. They wash them. They do it because they cannot sell it without washing. Why would that not be true of the apple growers as time goes on?

If the market demands a clean fruit the apple grower will have to wash. I cannot see why machines of the same type as that used by the citrus people would not clean the fruit and put a shine on it. They put paraffin on it to make it shine.

DR. T. J. HEADLEE: It may surprise most of the members here to learn that some of the earliest washing of apples was done in the state of New Jersey. If we can put machines into the citrus belt for that sort of thing—scrubbers and that sort of thing—they may get the same results as we did. What those scrubbers did to our apples was a fright. They were not marketable when the scrubbers got through with them.

MR. E. W. BERGER: Citrus fruits have to be handled carefully. They have made a lot of improvements in recent years so that the fruit doesn't drop for any great distance and the brushes will not injure the skin of the fruit. Of course, I recognize the fact that the apple has a different kind of skin than the orange.

CHAIRMAN CORY: This morning you heard of what splendid cooperation is being received from the authorities in Cuba. We are honored today by the presence of Dr. Sanchez Estrada, the chief of the Sanidad Vegetal of Cuba. It gives me great pleasure to present Dr. Estrada to you now.

PLANT QUARANTINE AND CONTROL IN CUBA

By ERNESTO SANCHEZ ESTRADA, *Chief, Sanidad Vegetal*

In the name of Dr. Eugenio Molinet, Secretary of Agriculture, Commerce and Labor of Cuba, and on my own part as chief of the Sanidad Vegetal, I wish to thank the association for the courtesy of the invitation to this meeting and for the opportunity of presenting an account of the work being done in Cuba upon plant quarantine and insect control.

Our department has always been eager to cooperate to the fullest extent with the Plant Quarantine and Control Administration of the United States for the mutual benefit of both countries by the prevention of insect and disease introductions and distribution.

The Sanidad Vegetal in Cuba undertakes all the work of the department pertaining to plant quarantine and insect and disease control. It was organized in 1915 largely as a consequence of the finding of the citrus black fly (*Aleurocanthus woglumi* Ashby) in Guantanamo, in the eastern part of the island, by Prof. J. R. Johnston and Dr. P. G. Cardin, and its first work was directed towards the limitation of spread of the pest, by said Dr. Cardin and Mr. Rodolfo Arango, Chief Quarantine Inspector of Sanidad Vegetal.

As a result of the introduction of this pest, and the necessity for controlling it as well as many others, there has been formulated a series of rules and regulations governing the handling of plant material within the island, and also of imports and exports. These rules and regulations are embodied in a series of presidential decrees and these have now been compiled in bulletin form.

The subject matter of these decrees may be summarized as follows:

Presidential Decree	
No. 1133	Prohibits the importation of citrus plants from all countries.
No. 1175	Prohibits the reexportation of potatoes to the United States.
————	Requires owners of coconut trees infected with "bud rot" to destroy them.
No. 1337	Regarding organization of the Sanidad Vegetal.
————	Prohibits the importation of sugar cane from all countries.
————	Requires shippers to secure export permits from Sanidad Vegetal.
No. 299	Requires owners of citrus groves infested with black fly between railroad lines to disinfect them.
No. 120	Prohibits the importation of cotton plants, fiber or seed.
No. 735	Requires all owners of plants infested with black fly to have them disinfected.
No. 736	Prohibits the importation of potatoes from certain countries.
No. 1850	Modifying decree No. 736, and permitting potato importations from United States, Canada and Canary Islands only.
No. 1314	Requires lima bean growers to take control measures against the "pod borer."
No. 1013	Requires inspection of gardens and nurseries and the certification before movement of plants.
No. 1541	Prohibits the importation of all fruits and vegetables from Chile, with certain exceptions.
No. 1555	Prohibits the importation of mangos and many other fruits from Texas.
No. 1556	Prohibits the transportation of plants without certification by the Sanidad Vegetal.
No. 1557	Prohibits the importation of green corn bushes and plants from several countries.
No. 1558	Prohibits the importation of broom corn except when accompanied by certificate of disinfection.
No. 1559	Prohibits the use of plants which are black fly hosts or parts thereof, for decorative purposes.

Congress Law	
———	Prohibits the export of pineapple slips.
No. 1551	Prohibits the importation of certain fruits and vegetables, plants, seeds from certain countries.
No. 1752	Prohibits the importation of second-hand cheese cloth unless fumigated.
———	Permits the importation of bulbs from Bermuda only through the port of Havana.
No. 667	Prohibits the export of pineapples of less than 36 to the crate size.
No. 861	Prohibits the exportation of immature fruits and vegetables.
———	Permits the importation of green lemons.
———	Annuls Decree No. 740, removing all restrictions against the importation of plants, fruits, vegetables, etc., from Florida.

I have brought with me a number of copies of the last annual report of the Sanidad Vegetal, which are at the disposal of any of the members who may desire them. This report gives a general account of the work during the year, with particular attention to demonstration and educational work in the control of injurious insects and diseases, the inspection of plants, fruits and vegetables, both for export and of imports, and with a list of interceptions of prohibited materials during this period. This inspection work covers the routine inspection of ship's cargo, passenger's luggage, postal shipments and of all airplanes arriving from, or departing for foreign ports. An account is also given of the periodic inspections of gardens and nurseries and the certifications for the movement of plant materials. I have with me a number of photographs showing various phases of the work of the Sanidad Vegetal, and these may be seen after the meeting by anyone who may wish to do so. I shall also be glad to discuss with the members any points relative to our work in which they may be interested.

The present organization of the Sanidad Vegetal comprises 15 port inspectors stationed at 8 official ports of entry, 15 inspectors of fruits and vegetables destined for export, 4 general field inspectors and 2 garden and nursery inspectors, in addition to an administrative force of 14 officials.

One of the important problems facing the Sanidad Vegetal since its organization has been that of the control of the citrus black fly. This pest has now spread practically throughout the island and to various other islands in the West Indies and to Panama as well. This rapid spread is of importance to the citrus growers of the United States due to the increasing danger of its accidental introduction there, and consequently the fullest investigation into the possibilities of control through various agencies was imperative. Dr. F. Silvestri, during the course

of an extended trip through the Far East some years ago, had observed and collected in Malaya a series of parasites which evidently were quite effective. As the fly was entirely free from such natural enemies in Cuba it was considered very desirable that these should be introduced as soon as possible into Cuba and other infested regions. The matter was discussed in detail between officials of the United States Department of Agriculture (Dr. A. C. Baker, Bureau of Entomology), the Cuban Department of Agriculture, Commerce and Labor (Mr. Ernesto Sanchez Estrada, Sanidad Vegetal, and Mr. S. C. Bruner, Estacion Experimental Agronomica) and of the Florida State Plant Board, Dr. J. H. Montgomery. It was finally agreed that this project should be initiated jointly between the two departments, the personnel to be provided by the United States Department of Agriculture and the funds for the field, work both abroad and in Cuba by the Cuban Department. The direction of the project was to be under the United States Bureau of Entomology (Dr. C. L. Marlatt, Chief). An agreement to this effect was drawn up and signed by the secretaries of the two departments on November 5, 1928. The foreign investigations were initiated in May 1929, at which time Mr. C. P. Clausen was assigned to the project. Mr. Paul Berry arrived in Cuba in January, 1929 to take charge of the breeding and colonization of the imported natural enemies, and was joined later by Mr. J. M. McGough. Headquarters for this latter phase of the work were established at the Estacion Experimental Agronomica at Santiago de las Vegas, near Havana, where insectary facilities were provided.

Dr. Molinet, Dr. Busto, Sub-Secretary of our Department and Major Vega, the Delegate of the Secretary in the Sanidad Vegetal, are very much interested in the progress of the investigations and have given every facility for advancing the development of the work.

I wish to assure you once more of the appreciation of our people for the efforts of all those who are assisting in the solution of this serious problem, and we are very much encouraged by the hopeful outlook at the present time. The successful outcome of this project would be of very great benefit to us in Cuba and would also greatly reduce the possibility of the introduction of the pest into the United States.

DR. E. R. SASSCER: I think we are fortunate in having Mr. Estrada with us today. I am confident you enjoyed the pictures and the remarks that he made.

I had the privilege of visiting Cuba in October and of observing the work which he was telling you of today. I want to take this opportunity of expressing gratification for the splendid work that is being

done in the Republic to the south of us, largely carried on through the untiring efforts of Mr. Estrada and the force of men that he has assembled. They are doing an excellent piece of work with the limited amount of funds that are available.

It is quite possible, in fact very likely, that in view of the success which he has had thus far, he will be given further support by his government in an effort to protect Cuba from invasion by other pests.

As you all know, in protecting Cuba he is protecting the United States as well. The disposition which he has shown to make an effort to stop the movement of infested plants or fruits, even suspicious fruits, to the mainland is certainly to be commended. It is not uncommon for his inspectors, as explained by Mr. Strong this morning, not only to inspect the baggage of the passengers coming to the States by plane, but by vessels as well. If roses are found in the possession of the passengers they are advised that in an effort to prevent the movement of the black fly to this country they would prefer that the flowers be kept in Cuba.

It is really a splendid piece of work that he is doing. Illustrating the thoroughness with which he does his work, I learned while I was down there—not through him but from other sources—that during the last year or so a rather valuable shipment of plants was forwarded to the President from some friend in Europe. Despite the fact that there was a quarantine prohibiting the plants coming in they were sent. Through the diplomacy displayed by Mr. Estrada he was able to persuade the President to forego the shipment and the entire lot was destroyed.

That is merely one of the many evidences of his efforts to prevent the entry of further pests. (Applause)

CHAIRMAN CORY: The next paper on the program is by Dr. Gilbert, who is not present. His paper is here and if time permits we will have the paper read after the presentations by those who are in attendance.

MAGGOT INSPECTION OF APPLES FOR EXPORT TO GREAT BRITAIN

By ARTHUR W. GILBERT, *Boston, Mass.*

The present situation in regard to the export of maggot infested apples started in the fall of 1929 when there was discovered in England by the British authorities several lots of American apples badly infested with the apple maggot. This discovery caused considerable agitation throughout the English apple-producing sections concerning the wisdom of permitting the importation of apples affected with this pest which is not indigenous to Great Britain. As a result of this agitation there was passed at a meeting of the Farmers' Union a resolution favoring an embargo on American apples.

In the meantime the International Apple Association took steps in this country to prevent further exporting of maggoty apples. Through a voluntary agreement on the part of the steamship companies a system of inspection was set up effective October 19, 1929, whereby all apples leaving Atlantic coast ports were required to be inspected and were accepted by the steamship company only when accompanied by an "Export Form Certificate" issued by the United States Department of Agriculture. This certificate was not issued if the fruit showed the presence of apple maggot.

However, even after the inauguration of this inspection service several maggot-infested shipments were reported as reaching England. Naturally these additional discoveries caused further agitation in England. The result of which was that the British Government took the matter up through diplomatic channels with the United States Government culminating in the "Importation of Raw Apples Order of 1930" issued by the British Government on or about June 21, 1930.

This order prohibited the importation of United States apples into England and Wales, between July 7 and November 15, unless the fruit was accompanied by a Federal Certificate of Inspection from the United States Department of Agriculture showing that the fruit was of one of the following grades: *Barrels* U. S. Fancy or U. S. No. 1. *Boxes* Extra Fancy or Fancy with no tolerance on maggot. This order was later made applicable to shipments to Scotland also and, of course, covered all shipments of apples from this country regardless of the type of package used.

The federal work in connection with the issuance of the Certificate of Inspection has been carried on by the United States Food Products Inspectors at the shipper's request either at the shipping point or the port

of exportation. Any evidence of maggot in the packages examined was sufficient to withhold that shipment from being exported to the British Isles as the steamship companies have refused to accept consignments unless accompanied by the above mentioned certificate.

Realizing the seriousness of the situation, and wishing to help in whatever way possible, the Massachusetts Department of Agriculture early in June, started a project on Apple Maggot Inspection with the following objects in view: (1) to determine the extent to which this pest is prevalent in Massachusetts orchards; (2) to bring the seriousness of the situation to the attention of the growers, help them to know the pest better, and suggest more effective control measures; (3) to improve the quality of apples intended for domestic as well as export trade and (4) in whatever ways possible to assist the federal inspectors with the inspection of fruit intended for export trade.

To carry out these aims the state was divided into several zones centering around the principal commercial apple growing sections with trained inspectors stationed in each zone. The work then proceeded along the following three lines.

1. Initial Survey. A general survey was first conducted. The inspectors visited individual orchards in a section to ascertain the presence of maggot, especially on early varieties. They also obtained from the growers information regarding the presence of maggot in other years, the spray program which had been followed and any other practices having a bearing on maggot control. Most of the growers showed a keen appreciation of this personal service.

2. Orchard and Apple Certification. This type of service was designed to give growers detailed information regarding the condition of their fruit in respect to maggot. A random sample of a variety was carefully inspected and the actual percentage of maggot infested apples determined. Inspection was made as near as possible to the time of harvesting so as to determine as accurately as possible the condition of the fruit as it would go to market. On the initiative of the growers inspections of this class were applied to fruit intended for domestic as well as export trade and were thought to be of considerable value to the grower of clean fruit in dealing with buyers.

3. Inspection of Apples for Export. The state inspectors in the several districts kept close watch on shipments intended for export that originated in their districts. They were present also at the shipping point or the port to assist the federal inspectors in the inspection of apples being exported if necessary and to furnish the federal inspectors

with information regarding the conditions found in the orchard in which the shipment originated.

As the above outlined plan was devised to help out in an emergency, it probably can be improved upon, but the essential features of it we hope to be able to continue until that emergency has been met.

CHAIRMAN CORY: The next paper is by Dr. T. J. Headlee.

LEGAL AND PRACTICAL ASPECTS OF THE RELATIONSHIPS BETWEEN THE FEDERAL AND STATE QUARANTINE OFFICES AND BETWEEN NATIONAL AND REGIONAL PLANT BOARDS

By THOMAS J. HEADLEE, Ph.D., *State Entomologist, New Jersey State Department of Agriculture*

ABSTRACT

Legal relationship comes into existence between Federal and State quarantine officers when an interstate plant quarantine, having intrastate features, is put into force within the United States. Practical relationships between Federal and State quarantine officers may rise from sources such as state instituted quarantines imposing restrictions that bear incidentally upon interstate commerce, and international quarantines which bear onerously upon some section or sections of the United States. To make these relationships efficient it is necessary that the Federal and State quarantine officers should make their plans and pursue their duties in a spirit of cooperation and mutual helpfulness.

In view of the fact that nearly all plant quarantines interfere somewhere, somehow with private rights and may constitute an interference with the legitimate business of large groups of our citizens, it is obvious that in addition to insect and plant disease distribution facts, the effect of such quarantine action upon the legitimate business, bound to be effected by it, must be considered as an important factor in determining when, where and how quarantine lines shall be laid. Quarantines must not only be laid with judgment and extreme care but they must be enforced with sympathetic consideration for the interests of those citizens whose legitimate business is being injured thereby and not in the spirit of the blood hound of the law engaged solely in the process of catching the evil doer.

The national plant board is designed to represent the interests of the regional plant boards where these interests are national in scope and serves in matters of this kind as a medium through which to present to the Federal Plant Quarantine and Control Administration the combined views of the state authorities. Naturally also the national plant board must think along national lines and afford leadership to the regional plant boards.

State and Federal quarantine officers usually come into a definite relationship to one another whenever domestic quarantines are enacted by the Federal Plant Quarantine and Control Service. Again the re-

lationship between Federal and State quarantine officers may arise when a state places a quarantine on its borders involving restrictions upon interstate commerce.

The legal aspect of this relationship has its foundation in the following facts: (1) the Federal authority is limited to interstate commerce and can, of its own motion, lay down a quarantine line only on State or international borders; (2) when the establishment of a quarantine line crossing a State or portion thereof is desirable such line cannot be laid by Federal authority but must be imposed by State agency. On the other hand, when a State lays down a quarantine line involving restrictions upon interstate commerce such quarantine is legal only in case the Federal authority has not seen fit to act in the particular matter concerned.

The practical aspects of these relationships involve the seeking and maintenance of a cooperative relationship by the Federal authorities where Federal quarantines are concerned and by State authorities where state initiated quarantines are involved. This cooperative relationship should always involve a matter of definite agreement between State and Federal quarantine officers and frequently also comprehends financial cooperation.

All that has been said thus far is the common experience of all State and Federal quarantine officers familiar with the legal and practical relationships that commonly exist between State and Federal quarantine officers. The writer feels much more inclined to discuss some of the fundamentals of plant quarantines than to continue further the attempt to record the above relationships. He does not propose to enter the field of human and animal health regulation because he is not sufficiently familiar with that phase of quarantine to feel that he has even the right to express an opinion concerning it.

International plant quarantines are the business of the Federal Quarantine and Control Administration although in a practical way they may very well become the business of State quarantine officers where they bear heavily and in an undesirable fashion upon the interests of the people in the territory over which they have supervision. Thus far the writer's experience has covered very few cases of this kind. The most outstanding example was, of course, the so-called Quarantine No. 37 forbidding the entry into this country of plants with soil about their roots. This quarantine undoubtedly bore very onerously upon certain large interests in this country and has made an enormous change in the conduct of the plant business, particularly that part which was concerned with ornamentals. While business has readjusted itself to the

operation of this order this readjustment has been made at a large cost to our people. At the time this restriction went into effect one experienced and very able nurseryman said to the writer, "After all it does not so much matter what the regulations are as the manner with which they are put into operation. The plant producer and distributor must have stability and continuity of policy. Notice of the beginning of the operation of a definite plant restriction activity should be promulgated far in advance in order that plant production and distribution businesses may make ready for the change. Likewise the notice of the proposal to cease particular plant restriction activity should be published long before it begins to operate. The length of time between the notice and beginning of change in these matters should be adjusted on the basis of the length of time necessary for the plant producer and distributor to rearrange his business." With this position the writer, as a State plant quarantine agent, finds himself in entire agreement. It is, of course, assumed in this discussion on the subject of international plant quarantines that no quarantine is ever laid by the Federal authority without having first intelligently and carefully balanced the anticipated benefits against the anticipated injury to the country's business and arrived at the conclusion that the former far outweigh the latter.

Domestic plant quarantines are essentially the business of both State and Federal quarantine officers. They are peculiarly difficult because almost without exception they comprehend serious to very serious interference with legitimate business and transgress the established principle of free interchange of commodities among the different states of the United States. Furthermore, they are susceptible of being used for commercial advantage. State and Federal quarantine officers, being essentially public service officials, have to be extremely careful in laying such quarantines to see that they comform absolutely to the best interests of the public.

Regardless of legal authority conferred by State or Federal laws upon the quarantine official it is his duty to impose no quarantine, which after a most careful balancing of prospective benefits with prospective injury, fails to qualify as promising to render far greater service than the harm which its operation will do. The writer feels, as a matter of public interest, that he cannot condemn too strongly any State or Federal law which does not require the responsible quarantine officer to make a most careful study of the prospective benefits and prospective injury of a proposed quarantine action before such action is taken and he feels that the quarantine officer would merely be carrying out, in a proper way, his status as a public servant by seeking changes in any law or laws

that fail to have this provision, to the end that such provision may be inserted.

Regardless of authority conferred upon the quarantine officer by any State or Federal law enabling him to place plant quarantines without sufficient notice to enable business to adjust itself, as a public servant he is under moral obligation to study and to determine in a most careful way the period necessary for this readjustment to take place and to give notice of the proposed activity sufficiently far in advance of its beginning to enable the businesses affected to adjust themselves to the proposed activity.

The proper basis of a proposed plant quarantine line is not alone the distribution of the insect or disease concerned but involves, as a very large and important factor, the effect of this line upon the distribution of the products to be restricted. Failure to consider this second phase of the basis not infrequently results in very large losses to producers, distributors, and consumers, far outweighing losses incident to the more rapid infestation of a territory not known to be infested at the time the quarantine line is to be laid. These losses are largely incident to the production of gluts in certain markets and paucity of supplies in other markets. The first type of loss falls upon the producer and distributor while the second type of loss falls upon the consumer. The writer realizes that the second phase of the basis of plant quarantines is one which has not received much consideration in the past but his experience clearly indicates that it should be given very careful consideration.

Plant quarantine lines following the outward distribution of an insect year after year inch more or less rapidly across the area of a State giving to the persons coming in contact with its operation the firm impression of failure and inefficiency and building up in the minds of the people who are affected, the firm opinion that all quarantines are inefficient instruments for the promotion of the public welfare. When to this impression is added the production of gluts in one market and paucity of supplies in other markets the producer, distributor, and consumer are confirmed in their unfavorable opinion of the public service rendered by plant quarantines. Due consideration, not only of the particular insect distribution, but also of the distribution of the commodities restricted, would, it seems to the writer, largely eliminate this undesirable and dangerous development of unfavorable public sentiment.

There are various ways of enforcing domestic plant quarantines but the only method that excites anything like the proper response in the public mind might be designated as sympathetic reasonable enforcement. If the object of the enforcement officer is apparently to catch

and punish the violator and, especially if he seems to get pleasure from carrying on quarantine work in this way the reaction of the public is certain to be unfavorable. Sympathetic and reasonable enforcement tend to minimize the resentment created in the minds of persons whose normal business is interfered with by the operation of plant quarantines and to allay the very human desire to get even with the enforcement officer and with the forces behind the plant quarantine. The enforcement officer should always be reasonable and should be very sorry when it is necessary to take drastic action and should leave the person or persons toward whom the action is directed of the opinion that such is his attitude.

The relationship between regional and national plant boards has no legal standing. The present national plant board is a creature of the regional plant boards and serves as a body representing the sentiment of the regional boards of the United States. It is composed of representatives elected by the regional boards and is expected to correlate their activities. The regional board is a creature of the States involved in the territory which it covers and therefore has no legal power to compel action upon the part of these states. The moral and influential power of the regional boards and of the national board is really tremendous. Furthermore, a combination of the regional plant boards and the national plant board serves as an agency to express in a definite way the sentiments of the different States of the United States relative to plant quarantine matters. The national plant board is and should be in a position to speak definitely and clearly to the Federal Plant Quarantine and Control Administration on any matter or matters relative to plant quarantine in which there is a general agreement among the regional plant boards. On the other hand, where the matter concerns primarily a regional plant board the regional plant board is in a position to speak directly the minds of the states concerned to the Federal Plant Quarantine and Control Administration.

CHAIRMAN CORY: Dr. Headlee's paper is before you for discussion.

MR. L. A. STRONG: I think Dr. Headlee's paper is a most excellent one. I am wondering whether I understood correctly the expression that in taking off a quarantine a long time should be given, that is, a long notice before the quarantine is taken off. It strikes me that there might be cases where a quarantine was put on in all good faith. Then, after making a careful study of all circumstances after the quarantine had been put on for some time—maybe several years—conditions might be found to have changed in one way or another making that

quarantine no longer necessary. It might be said that in some instances the quarantine is not at all desirable. It doesn't seem to me that it would be necessary or right to give a long notice before that quarantine could be taken off. Certainly, once the quarantine is taken off conditions will very rapidly adjust themselves.

In Quarantine No. 37 we are dealing with one which has for its fundamental purpose the reduction of the importation of pests and the cutting down to a minimum the importation of plants. In order to bring about the maximum of safety a plant supply had to be built up, which was incidental to the quarantine and which was not its purpose.

I can easily understand that under that quarantine certain regulations here and there may be out of joint and can be taken off right now. It might have a detrimental effect on certain lines of commerce if it were not taken off. Why should we give a long notice when we are going to take off the quarantine anyway? Maybe I misunderstood your point. I do think there are cases where a quarantine can be taken off without a long notice.

DR. T. J. HEADLEE: I tried to state that the length of time allowed would be dependent upon the results of a study as to the changes that such action would bring about. If it so happened that the restriction could be taken off in 24 hours, or immediately without any serious consequences to business, and the quarantine officer knows that to be the case, he is justified in taking it off.

The thing that I wanted was a sliding scale. For instance, if you take off Quarantine No. 37 at the present time it would be a terrible thing for certain lines of business in the country. It would occasion tremendous losses running into millions of dollars in a year. That is the other side of the question.

MR. L. A. STRONG: We have to realize that when we get right down to the foundation of quarantines that in one way or another they are all economic. In none of this quarantine business can we overlook econnomics. We have to take that into account every time. I wanted to bring out that point clearly.

MR. VAN BUREN: The same point would apply to all of them. There is a possibility of having a hearing on the bulb quarantine question shortly. We have something of a problem on Long Island and in the Northwest on bulb plantings, in which millions of dollars have been invested. That is dependent on quarantines. If the quarantine is removed there is no question but that the industry would go back to Holland, at least the Long Island industry would.

CHAIRMAN CORY: Is there any further discussion? Dr. Headlee stressed the need for cooperation between the state and federal authorities. I think I speak the mind of all state officials when I say that the present administration and the past administration have left nothing to be desired in that way.

The next paper is by L. M. Fenner of Columbus.

BACTERIAL CANKER OF TOMATO AND ITS DISTRIBUTION WITH THE SEED FROM INFECTED FRUIT

By L. M. FENNER, Formerly *Associate Plant Pathologist, Mississippi State Plant Board, A. & M. College, Miss.*

ABSTRACT

Bacterial Canker of Tomato (The Grand Rapids disease) is partially controlled by seed treatment with bichloride of mercury at the rate of 1: 3000 parts of water for five minutes. Infected and contaminated seed, if untreated, may be responsible for percentages of canker varying from one to one hundred percent in the field grown plants. Seedling infection occurs usually in the plant bed. The severity of the primary infection of the plant is considered important in relation to subsequent infection of fruit and seed. Seed infection is not always coincident with the systemic infection of the plant. Preliminary work has shown bacterial infection in two percent or less of the seed from infected fruits. Contaminated seed was present in much higher percentages. Further knowledge of the external and internal symptoms of this disease is essential to the practical control of the sources from which diseased seed may originate.

It is known that bacterial infection will appear in plants grown from tomato seed which is contaminated and infected with *Aplanobacter michiganense* EFS. The seed trials and disinfection experiments of Boyd in Georgia during 1929 indicated that disinfection of the seed with bichloride of mercury solution at a concentration of 1:3000 parts of water for a period of five minutes was adequate for the control of the surface borne bacteria. The earlier work of Miss Mary K. Bryan has emphasized the effectiveness of the inorganic mercury treatment. The organic mercury dusts apparently have given incomplete control. In new land, tomato seedlings from the treated seed lots have shown small amounts of the disease. Further investigations by Miss Bryan have shown the bacteria to be just beneath the seed coat at the point of attachment to the funiculus.

The amount of seed infection resulting in the fruits harvested from plants with systemic infection is not definitely known. Observations in several tomato production centers have shown that contaminated seed may give one to one-hundred per cent infection in field grown plants. It

is a safe assumption that the fermentation process of saving seed does favor a rapid increase in the causal organism. At the same time, there is the probability of an increase in seed infection. Immediate disinfection before drying the seed would eliminate the surface borne bacteria. Even after seed treatment the seedsman or the producer could not assume that the seeds were free of the organism. Hence, it seems pertinent to study more thoroughly the disease in the field to ascertain the percentages of fruit and seed infection.

The severity of bacterial canker infection and the time of its first appearance in the plant may be of interest to quarantine officials. In some areas of the United States, the detection of the disease appears to be a simple matter. In other localities, the disease might be overlooked or mistaken for one of the fungus wilts. Under certain conditions with a small percentage of canker present in the field, the relation of the organism to seed infection may not be highly significant. From observations of the tomato crop in Mississippi during 1929 and 1930, it appears that the disease is favored by a certain soil moisture content, a relatively high humidity, and temperatures of 80–95 degrees Fahrenheit. In 1929, moderate to heavy rainfall prevailed and optimum growth of plants occurred. Maximum infection occurred between June 1–10. In 1930, precipitation was at the maximum on May 18 with temperatures of 95–100 degrees F. prevailing, thereafter until late in July. Canker infection during 1930 was most severe and destructive from May 15 to May 31, diminishing in severity after June 1 as the drought period was approached. Fruit production from all fields, both disease-free and canker-infected, was greatly reduced. Yet it should be noted that the production from a canker field in a year of drought is greater than the harvest during a normal season. A study of the factors for optimum growth in the tomato plant may show a close correlation with the factors favoring the growth of the organism.

In the field grown plants of Mississippi, typical canker symptoms appear when optimum growth conditions exist. Open lesions on the main stem, petioles, midribs of leaves may occur during moist, humid weather. These diagnostic characters may appear in the field of plants after sixty to ninety days or even a longer period of incubation. Experimentally, the disease is reported to have appeared within two weeks under greenhouse conditions. With a reduction in the severity of infection, the number of open cankers is reduced to zero or to a very small percentage especially during a dry season. Fruit malformation, fruit spotting or cankering are greatly lessened, although the bird's eye spot may appear when heavy dews fall.

In the seed-bed stage, the determination of seeding infection is not entirely satisfactory unless the infection is severe in the roots. In the greenhouse, inoculated seedlings have shown root decay of the main axis and secondary roots followed by the development of many new roots. Severe root infection can be traced to the cortical tissues and into the central cylinder. The reddish brown of the decayed root becomes lighter in the rapidly growing transplant, making detection of infection difficult in the stem at the ground line. It is assumed that severely infected plants decay in the plant bed but those with lesser infection may persist for two to eight weeks, often becoming necrotic before bearing fruit. Other infected plants may be necrotic when the first and second fruit clusters have set or become half-matured. In the most vigorous plants with systemic infection, leaf symptoms or cankers may be delayed until three or four clusters are greatly advanced in growth, at which time a severe disintegration of the parenchyma-vascular region of the stem occurs.

The question arises, finally, as to the amount of seed which may be contaminated or infected within a given fruit of a plant with systemic infection. The rapidity with which the bacteria reach the fruit pedicel and enter the fruit can only be estimated at present. The first fruit clusters may become infected quite early in the season. The successive clusters may or may not be infected according to the severity of the disease and certain factors that are but little understood. Fruit infections are difficult to find except where early infection of the main stem and fruit pedicel are greatly advanced to the point when malformed and stunted fruit result. Fruit in the pre-pink or pink stage, even when taken from infected pedicels, rarely show the yellow bacteria in the vascular elements leading to the funiculus. Occasionally, ripe fruit has been found to be infected yet there was no external evidence of infection. A comparison of the above factors and conditions in the south with the tomato seed production factors in the northern and western areas should be helpful in arriving at practical control measures.

Tomato seed from canker infected plants and from disease-free vines was saved from Mississippi fields in 1930. A part of the fruit was washed to remove the debris. The other fruits were washed and then treated with bichloride of mercury at a concentration of 1:1000 of water for five minutes. The seeds were removed aseptically with a knife and spatula. At that time data were obtained on the amount of fruit and seed infection. A comparison of these seed with those of other lots grown both in Mississippi and in other states has given some data on seed infection. Seed of the sixty-eight fruits from Mississippi plants of 1930 has shown

less than two per cent infection while seed produced elsewhere has shown a trace or above one per cent. This examination is based on the external and internal appearance of the seed and not on pure culture isolations. More than seventy-five per cent of the fruit from the Mississippi collection showed infection either when the seed was extracted from the pulp or at the time of seed examination five months later. Attention is called to one instance where two fruits were saved from a single plant, presumably disease-free, in a canker field. This fruit yielded infected seed. The actual contamination in these seed lots from various sources is considered to be ten per cent and above. This percentage is yet to be determined. The significant point in these preliminary studies is that a small amount of infected seed may give rise to a moderately high percentage of diseased plants, while contaminated seed usually gives a very high percentage of infected plants. Comparative trials of infected and contaminated seed are required to determine the importance of the small amount of infected seed which result from systemically invaded fruits or from the exposure of the seed coats to the bacterial organism.

CHAIRMAN CORY: The next paper on the program is by E. R. Sasscer Washington.

EXPORT CERTIFICATION POLICIES AND RESULTS

By E. R. SASSCER, *Washington, D. C.*

(Withdrawn from publication)

DR. T. J. HEADLEE: This is a subject which many of us are slightly interested in because, while the percentage and the volume of country production that is exported is pretty small, it is removing the last straw that breaks the camel's back in the matter of domestic price.

I will say that the states in the Eastern Plant Board District have been much interested in it. The plan of certifing for export on the basis of grade has never appealed to many of us as being very sound. Really, the certification ought to be on the organism concerned, which, of course, on fruit that goes to Great Britain, is the apple maggot.

I have always had a fear that in the examination of a few samples to determine the condition of a large shipment, the inspectors might overlook something which would be picked up on the other side and might prove serious indeed.

Some of us have been wondering why some scheme could not be worked out cooperatively with the states so that orchard inspections

and statement of condition could be made, with, of course, the federal certificates being issued by the federal employees.

I have a feeling that there should be some combination between the inspection officials of the states and of the federal government by means of which these things can be adequately taken care of to the end that our export market may grow rather than diminish. I believe the export market is extremely important from the standpoint of the growers, at least in the Northeastern states.

MR. L. A. STRONG: I would like to say that the suggestion presented by Dr. Headlee was given in the form of a suggestion, either by him or someone else, to the State Department for transmission to some of these foreign countries. That was handed in some two or three months ago. They seemed to be perfectly satisfied with the type of inspection that was going on. I agree with Dr. Headlee that basing the condition of the carload on the inspection of one sample is dangerous. I would like to get away from it.

MR. E. R. SASSCER: In regard to the point raised by Dr. Headlee relative to a joint inspection; that is something that we have had in mind for the last three or four years. We would like to find some way of working out the problem.

It occurs frequently that these shipments are for export trade but they are kept in a New York warehouse even though they have been raised in West Virginia or Virginia. When they get an order, they just move so many. In other cases they are shipped direct. Perhaps in the case of those being shipped direct the matter could be simplified.

As a matter of fact, we have a cooperative arrangement with the Bureau of Agricultural Economics and the state officials, on the Coast, in handling shipments when we know they are going direct from the packing house to the dock and then on. However, we do get many shipments in New York that no one realizes are meant for export when they arrive.

With regard to the sample examination: I do not even intend to offer an apology for that. It is all we can do with the force available. Anyone who has visited one of these large ports fully appreciates the conditions which obtain on the docks and in the warehouses and the difficulty of making a very thorough-going inspection. I can assure you that such apples and pears and plums as are examined are examined carefully and by the best men we have in our service.

DR. T. J. HEADLEE: I do not want to give the impression of being dissatisfied with what we have. We are getting the utmost with what

we have. I would like to see something more extensive and certain developed. To that end, there is a committee that has been appointed from the Eastern Plant Board to cooperate with any and all who are especially interested to see whether some cooperative plan cannot be worked out. Dr. Gilbert is the chairman of that committee and we had hoped that he would be here today to discuss the matter. Unfortunately, he is not present.

CHAIRMAN CORY: Dr. Gilbert's report is here and he stresses orchard certification and the cooperation between state and federal officials at the port as well as at the loading point.

If there is no further discussion we will pass to a paper to be presented by A. F. Camp.

RECENT INVESTIGATIONAL WORK ON FUMIGATION IN FLORIDA

By A. F. CAMP and J. R. WILMOT, *Gainesville, Fla.*

(Withdrawn for publication in the Monthly Bulletin of the Florida State Plant Board, Vol. 15, Nos. 5, 6, 7, 8, p. 1–35, 1931)

CHAIRMAN CORY: We are ready for the discussion.

DR. T. J. HEADLEE: I wonder if the worker has made an attempt to determine whether there is enough gas taken up by the plants to make them seriously toxic for ultimate consumers?

MR. A. F. CAMP: We have done very little work with that. There was considerable done in the past. But, as an example of some actual practical application of the process of fumigation, commercial men fumigate restaurants.

There is some indication that things of a watery nature, or with water in solution, might take up enough to be toxic if exposed to high concentration. But, ordinarily this is not true.

CHAIRMAN CORY: We will now pass to the report of the National Plant Board, including a report on the principles of Plant Quarantines.

SUMMARY OF ACTIVITIES OF THE NATIONAL PLANT BOARD DURING 1930

Three meetings of the National Plant Board were held during the year 1930,—one at De Moines during the annual entomological sessions, a second at Orlando, Fla., from January 11 to 15, and a third at Washington, D. C., November 18–19.

The Florida meeting enabled the Board to become acquainted with the eradication work of the Mediterranean Fruit Fly. The meetings included an eight hundred

mile trip throughout the southern part of the state. The Washington meeting enabled the Board to meet with the officers and project leaders of the P. Q. C. A.

The activities of the Board have been varied. In keeping with its constitutional purpose, it has carried out the instructions of, and represented the regional boards. It continues to strive for uniformity and efficiency in the enforcement of plant quarantines, maintains advisory contacts with Federal and state quarantine bodies, and acts as a clearing house on quarantine and inspection policies.

The Board has striven for publicity in Federal quarantine matters; has discussed and recommended inspection of docks, ships and airplanes engaged in international transportation; has urged the further investigation of foreign plant pests; has thoroughly studied the reshipment of imported fruits from the port of entry, which fruits might be infested by a foreign pest; has considered the matter of crop loss compensation; and has given attention to such major insects and diseases as the pink boll worm, Argentine ant, Alfalfa weevil, Japanese beetle, Mediterranean Fruit Fly, Larch Canker and Phony disease of peach.

In addition to these major matters, the Board has discussed at length the "Principles of Quarantine" in their original and revised form and is about prepared to submit to the regional boards for approval, a set of principles covering quarantine matters in a more extensive manner.

The board has received a total of $450.00 from the four regional boards since its organization. It has a balance of $341.83 in its treasury.

Respectfully submitted,
R. W. LEIBY, *Secretary-Treasurer*

CHAIRMAN CORY: Professor O'Kane, have you a report to make on Plant Quarantine Principles?

INFORMAL REPORT ON THE PRINCIPLES OF PLANT QUARANTINES

By W. C. O'KANE, *Durham, N. H.*

I think it was three or four years ago that the matter of drawing up a set of principles that might be considered as applicable to any quarantine was first suggested. Dr. McCubbin, then secretary of the National Plant Board, set to work, drew up a statement of some of the underlying facts and considerations with a statement of principles. That was later submitted to the Regional Boards after some discussion by the National Plant Board.

Various changes, omissions and additions were suggested by the Regional Boards, especially by the Western Plant Quarantine Board. At the last meeting of the National Plant Board at Washington, a short time ago, one whole evening was spent in further discussion of the principles of plant quarantine. Since that time some further discussion of the principles has taken place by mail.

This may not seem important. I am not prepared to say how important it is, but there must be various underlying considerations that would apply to plant quarantines (and to other quarantines, for that matter). The rules and regulations would change from time to time I suppose. We believe that to be so. In other words, they would change in the light of further experience and further knowledge on the part of those administering quarantines.

Yet, in the light of present experience and present knowledge it ought to be possible to crystallize certain broad statements that would be helpful in judging the merit of a

given quarantine, whether state, federal or local, or whatnot; they would be helpful in the job of drawing up quarantine measures relating to new emergencies.

As we have gone further and further into the matter we have discovered unthought-of factors to take into account. It is still in the process of being done and I suppose it will always be in the process of being done.

The National Plant Board hopes and expects to be able to transmit to the Regional Boards, and through them to the state quarantine officials, at least what would seem to be a reasonable statement of principles as we look at them now. They will probably take up a dozen or more factors, some of the prerequisites that ought to prevail with reference to the establishment of a quarantine, the relations of quarantines to the public, inter-relations of the various authorities that are concerned in the administration of many quarantines, the need for making a quarantine as extensive and inclusive as it ought to be, and no more extensive or more inclusive than it ought to be.

They will take up the need for prompt modifications of quarantines, or their prompt repeal, if they have accomplished their object or it has been determined that the object cannot be determined thereby. They will take up something of the scope of a quarantine, depending upon its objective, perhaps something to the effect that a quarantine that is established for the sake of attempting an eradication campaign may be greater in its scope and more intensive in its measures, because of the nature of the objective and because of the time element involved than would be a quarantine laid down merely to prevent, or retard, the spread of a pest without any eradication in view.

There will be considerations of that kind. The latest version of it is in my hand, but I am not going to read it. It isn't ready to be read as yet. It is being considered now by some of those most interested. I am willing to read the topics that it covers. They are these:

Definition of a quarantine; the basis and logic of a quarantine; why a quarantine is basically a logical thing under certain emergencies; the prerequisites that should underlie any quarantine; the necessity for legal sanction having adequate law and for staying within it; necessity for validity, that is the establishment of a quarantine for a legitimate purpose, and not ostensibly for one purpose when an entirely different purpose is the real objective. I am told we have some laws of the latter type.

Necessity for giving public notice, if it can be done, and the equal necessity of going ahead without public notice if such notice cannot be given without jeopardizing the objective that is sought; the scope of a quarantine; the relation of a given quarantine to eradication, and, on the other hand, the relation to such an objective as retarding the spread of an insect or plant disease; cooperation of authorities, federal, state, local; cooperation of the public. I happen to be one of those who believes that the cooperation of the public is more or less essential in the complete observance of a quarantine. Complete observance may mean all the difference between success in obtaining the objective and failure to obtain it.

Clarity. We have some quarantines that could be improved in that regard, of course. Keeping the public informed. In other words, not only the officials of the various agencies concerned, but the general run of the public.

Relation of a quarantine to research. We never know as much as we ought to know about anything. That certainly is true with regard to a plant disease, or an insect pest the occurrence of which has become the basis for a quarantine measure. On the other hand, it may be essential to go ahead on the basis of present knowledge

immediately without any delay. Along with that it may be desirable, and we should be willing and able to institute research in order to further perfect the workings of the quarantine and eventually get rid of it, or make it succeed, as the case may be.

There are the subjects of promptness, proper scope and repeal. There is the matter of notices to parties that are interested in a quarantine, both in its promulgation, its modification and its abandonment or repeal.

The National Plant Board believes that it would be helpful if a statement of some of these matters could be made soon. It would be helpful to all of us and would help us to crystallize our thoughts. It would be helpful to the public, and would possibly be helpful to the law-making and appropriation-providing bodies.

CHAIRMAN CORY: First we will hear from Dr. Headlee the chairman of the Eastern Plant Board.

REPORT OF THE EASTERN PLANT BOARD

THOMAS J. HEADLEE, *Chairman, New Brunswick, New Jersey*

The annual meeting of the Eastern Plant Board was held on November 24th in New York City. Twelve of the thirteen states were represented. Dr. C. J. Drake and Mr. Millen of Ames, Iowa, and Professor J. S. Houser and Professor Harry F. Dietz of Wooster, Ohio, attended the afternoon session.

Consideration of the Narcissus bulb quarantine situation developed the fact that the sense of the meeting held it to be unsatisfactory in certain respects and that certain changes should be made. No further action was taken in view of the fact that the board was informed that Mr. Strong of the Federal Plant Quarantine and Control Administration was contemplating a hearing on this subject sometime in January or February, 1931.

The matter of digests and indices for existing quarantines was considered and Dr. Adams, the Plant Pathologist representative of the Eastern Plant Board on the National Plant Board, stated that the matter had been presented to the Federal Plant Quarantine and Control Administration and that he thought such digests and indices would be prepared for general distribution.

The Woodgate rust quarantine came up for a rather thorough overhaul. It was the sense of the meeting that arrangements should be made with the Plant Quarantine and Control Administration to make a very extensive survey of all plantings within the region where Woodgate rust occurs but that for the present the quarantine should be allowed to stand.

Mr. H. L. McIntyre then favored the Board with a statement of the Gipsy moth situation. Apparently there has developed immediately east of the barrier zone in the region of eastern Massachusetts and Connecticut a heavy infestation of Gipsy moth and that from these infestations three jumps have been made west of the Hudson River. These slight infestations have been cleared up but the problem of holding the barrier zone under these conditions has become increasingly difficult. Mr. McIntyre believes that it will be necessary to suppress the infestation immediately east of the barrier zone if the barrier zone is to be held as a successful bar to the westward and southward distribution of the Gipsy moth. The appointment of a standing committee from the membership of the Eastern Plant Board was authorized and the business of this standing committee was to see to it as far as possible that funds necessary for the suppression should be provided. The committee consists of Mr. H. L. McIntyre, Dr. W. E. Britton and Dr. Thomas J. Headlee.

After giving a considerable period of time to the discussion of difficulties met with in carrying out certain quarantines, especially for Japanese beetle in the Eastern Plant Board district, it was held that the only way to minimize these difficulties and injury to production and distribution of products restricted was to have research on methods, by which the producer and distributor can conform to the restrictions and keep pace with the needs. A resolution to this effect was prepared and ordered transmitted to the Federal Secretary of Agriculture and to the Chief of the Federal Plant Quarantine and Control Administration.

The Board was informed by Professor W. C. O'Kane, its entomological member on the National Plant Board, that the principles of quarantine had come up for examination by the National Plant Board, that they had been revised and that they would shortly be transmitted to the regional boards for further consideration and action.

Professor O'Kane then brought up the matter of Senate Joint Resolution No. 9 and Senate Committee amendment thereto. The purpose of Senate Joint Resolution No. 9 was apparently to enable men in the states to enact state quarantines in animal work. The Senate Committee amendment provided that if the Federal Secretary of Agriculture believed that any such state quarantine was unwise he could nullify it. The Eastern Plant Board took a position in opposition to the amendment.

The present status of the Dutch elm disease was then presented and it was decided that the Plant Quarantine and Control Administration should be requested to give it immediate attention and that the Bureau of Plant Industry should ask for adequate appropriations to take care of investigations. Further action was taken directing the secretary of the Board to present this matter to the proper officials in Washington and to see as far as practicable that adequate appropriations are to be provided.

Dr. Gilbert, chairman of the committee on the export apple situation, presented a progress report showing that the belief of the English authorities of the dangers of the receipt of apple maggot infested fruit from the United States was a matter of real concern and that Massachusetts had put on a system of state inspection of apple orchards which had apparently afforded material help to the growers in that state in the matter of getting maggot free fruit to the export market. By implication Dr. Gilbert indicated that a similar attack of the problem in the other states of the Eastern Plant Board district where apples are grown for export would be likely to be followed by excellent results.

CHAIRMAN CORY: Is there any discussion of the report?

Mr. Chambers will present the report for the Central Plant Board.

REPORT OF CONTROL PLANT BOARD

By E. L. CHAMBERS

The sixth annual meeting of the Central Plant Board was held on March 6 at Lafayette, Indiana. It was presided over by Mr. Wallace, then president. It was attended by 18 inspectors, representing nine states, Iowa, Illinois, Indiana, Michigan, Minnesota, Missouri, Nebraska, Ohio and Wisconsin.

The principal topic discussed, which was of interest to the Central States, was Federal Plant Quarantine No. 38, which the Central States have been endeavoring

to have amended in order to prevent the movement of susceptible varieties within the states included in the infected area. The quarantine as it stands prevents the movement of susceptible varieties into the infected areas, which include the Central States, but it does not regulate the movement from one state to the other within that area.

Another subject was alfalfa weevil quarantine, which was a matter of intense interest because we wish to keep up with increase in the extent of the area infested, and wish to prevent the weevil's introduction as long as we can. There was a feeling in the meeting that this could well become a subject for the Federal Plant Quarantine and Control Administration. We hope that some day they will see it that way.

One of the features of the meeting was a report by Professor Ruggles, our representative to the National Board, of the National Plant Board meeting held at Florida. He gave us a very interesting discussion on the Mediterranean fruit fly and the other projects that the National Plant Board were working on.

Two resolutions were introduced and passed. One of them was on the subject of infectious yellows on roses. The resolution was sent to the Secretary of Agriculture requesting that a survey be made to determine how extensive was the spread of this disease and what, if any, source could be tapped for an American-grown stock that would be satisfactory for propagating purposes.

In addition, a resolution was passed because some of the members felt an attempt was going to be made to shut off the importation of manetti from foreign shores. A resolution was passed asking the Plant Quarantine and Control Administration to delay any such action until adequate source of satisfactory stock could be secured.

In addition to these subjects, the question of the spread of the Oriental fruit moth and the peach yellows through nursery stock came up. No satisfactory evidence was presented that either of these would be spread or could be controlled by the handling of nursery stock in any other way.

The other subjects discussed were uniform tax, dealers' licenses, transportation signs for the prevention of movement of trees and shrubs by tourists.

Professor Ruggles gave us a discussion of two scale insects that have been doing injury, serious injury, in Minnesota and the adjoining states.

There is one other problem we have, which I was in the hope of hearing someone else bring up. That is the matter of finances. We do not have compulsory dues in our organization. We suggest that each state pay $40. Some of the states have not been able to pay this amount. During the past year about seven out of the 13 states were able to pay the complete dues of $40. One of them paid $10. We find that it will be difficult to meet some of the requests for finances to the National Plant Board and to take care of all the expenditures we have unless we find some way of getting funds. I was in the hope that the other Boards would have the same problems and would have them solved. Apparently, they do not have those problems.

It was voted to dispense with the reading of the report of the Western Plant Board, printed below.

REPORT OF THE WESTERN PLANT QUARANTINE BOARD

By W. C. JACOBSEN, *Sacramento, California*

The 1930 meeting of the Western Plant Quarantine Board was held at State College, New Mexico on June 12 to 14. Officers elected were Dr. H. L. Kent, President, New Mexico College of Agriculture and Mechanical Arts, as Chairman; A. G. Stephens, State Entomologist of Wyoming, as Vice-Chairman, and W. C. Jacobsen.

Secretary and representative on the National Plant Board. The chief activities are best indicated through a summary of important resolutions passed and of matters discussed at the last meeting.

1. It was recommended that a comprehensive study of pests now existent in foreign countries and which are potential menaces to American agriculture be made in such countries through a coordinated program worked out by the Secretary of Agriculture. The Plant Quarantine and Control Administration, the Bureau of Entomology, and the Bureau of Plant Industry of the Department should cooperate in this undertaking. The object is to have in our own scientific literature information on habits, types of damage and suggestions for control or eradication from actual foreign study rather than have much of this work to do after the arrival and establishment of the insect or disease in the United States. It is recognized that differences in climate, hosts and environment present some difficulties, yet much data could be accumulated which would be helpful in an emergency.

2. Request was made to the Chief of the Plant Quarantine and Control Administration to have summarized the available data on treatments for elimination of insect pests and plant diseases on commodities subject to quarantine restrictions. It is recognized that much data are available through the scattered literature. The proven facts should be compiled. With that as a basis, future work along such lines could be planned, investigations made, and safeguarding treatments listed. Centralization of such data in one interested organization seems a sound policy and will prevent duplications in this important pest suppression field. The work already done by certain federal agencies can be turned to good use.

3. It was recommended that a compilation be made, preferably through the Plant Quarantine and Control Administration, with the aid of the Solicitor of the U. S. Department of Agriculture, of all cases, briefs and decisions pertaining to regulatory work of a quarantine nature. Much legal data are available but scattered nationwide in law books, reports, and decisions. A careful compilation available at a central source could well serve as a guide in drafting statutes or regulations in such a manner that their enforcement would not so likely be hampered by court action. The experience of others can be made an invaluable aid in avoiding legal pitfalls. Even our attorneys would welcome such data.

4. The Board petitioned the transportation companies and allied agencies to utilize, as equipment for the movement of plants or plant products, cars of a construction relatively free of nooks and waste spaces in which important agricultural pests might be harbored. The use of single-walled box cars (i. e. cars with the supporting beams on the outside, thus eliminating a false wall inside) was suggested for commodities such as flour, grain, alfalfa meal, seed, etc. This would eliminate many hiding places for pests.

5. The Cotton Pink Bollworm eradication project was endorsed and the Secretary of Agriculture was asked to negotiate with Mexico to develop a uniform program looking to the elimination of this pest from the North American continent. It was stated that Mexico now has a pink bollworm eradication project under way.

6. The Secretary of Agriculture and the Plant Quarantine and Control Administration were commended on progress made toward the eradication of Mediterranean fruit fly in Florida, also other agencies which cooperated to that end. The Board recommended that a survey for the pest be continued not only in Florida but in adjoining states to gain assurance of its absence from areas to which infested fruits might have been shipped prior to the effective date of the federal quarantine No. 68.

In this same connection, other states were petitioned to make surveys within their boundaries for the same reason, especially in view of the apparent shortage of funds available to the federal department, because of the unfavorable attitude of the House Appropriations Committee.

This leads to a consideration of the importance of pest survey work on the part of all states maintaining a regulatory service to keep out pests. Much inspection work is now primarily devoted to nurseries and greenhouses. Incipient infestations in other quarters are frequently not encountered until too late for eradication. Adequate survey personnel and skeleton organizations for quick action against important newly introduced pests should go hand in hand with quarantine enforcement.

7. Uniformity in apiary inspection laws and regulations governing the interstate movement of bees and accompanying equipment took an important place in our discussions. The legislatures of the several states meeting in January, 1931, will have revision in apiary inspection laws up for consideration. The western states have agreed that burning is the only sound method for the eradication of American foul brood.

8. From the angle that weeds form an important role in serving as intermediate or even obligatory hosts of many pests destructive to agricultural crops, the Western Plant Quarantine Board has asked the Secretary of Agriculture to co-ordinate under one executive head within the U. S. Department of Agriculture all of the weed control activities of the department which are now scattered throughout a number of bureaus, services, offices, and divisions. This is primarily for the purpose of having one central agency within the department from which the states could secure sound data on weed control and which agency would also engage in a *basic* weed control research program. This would avoid duplication in many instances on the study of basic problems common to many weeds. It is recognized that local studies must be made but it is felt that these can be aided through the U. S. Department of Agriculture with fundamental suggestions and information. No quarantine measures against weed seeds have been suggested although in some western states shipments of farm and garden seeds are rejected because of noxious weed seed content. If sound practices can be developed for keeping weeds in check at a low or nominal cost, there is not likely to be any great development in weed seed restrictions, but if states continue to neglect the weed problem and research on control does not develop, there is bound to be an increasing demand from progressive agriculture to keep new weeds from entering areas free of types known to be serious pests and hosts of insects and diseases which detrimentally affect commercial crops.

9. Placing authority in the hands of the Secretary of Agriculture to declare state quarantine enactments or promulgations null and void, if upon investigation he may find them too drastic or unwarranted, as provided in a live stock quarantine amendment now before Congress (S. Joint Res. 9 and House J. Res. 326), was considered inadvisable in the case of plant quarantines. The several states have grouped themselves into regional boards headed by the National Plant Board for the purpose of giving consideration to uniformity in quarantine practices, to discuss the principles involved in quarantine provisions, and to avoid controversies which might result in retaliatory or subterfuge quarantines. In other words, the states are doing for themselves all that the Secretary of Agriculture could do in the case of pests concerning which he had not seen fit to take action by issuing a federal domestic quarantine. The Board felt that there should still be reserved for the states the inalienable right to protect the property and welfare of their citizens whenever no superior authority had taken steps to do so.

10. The Western Plant Quarantine Board has also suggested that one of the purposes for which the Federal Plant Quarantine and Control Administration was organized has at least in part been neglected; namely, that the eradication or control programs against insect pests and plant diseases which are the subject of federal quarantines should be vested in the Administration. The objective is to have a well-trained personnel engaged in control and eradication work, unhampered by the delays attendant upon digressions for supervising research projects not always directly relevant to success. This seems too important to postpone further. The success of the Medfly program is an example. Research played an important part but it was all directed to the objective of eradication.

11. Alfalfa meal has been found, when surrounded by adequate safe-guard against contamination from alfalfa weevil and when properly milled in approved mills, to be safe for shipment the year around and not a hazard for the introduction of alfalfa weevil. The alfalfa meal committee of the Western Plant Quarantine Board has studied requirements necessary to safeguard against spread of this pest through milled meal and recommended a modification. California has already provided for admission of such meal throughout the year. This same state has incidentally revoked two quarantines, one against the so-called Navel orange worm (*Myelois venipars*); the other against strawberry root weevils, indicating the trend to adhere to the important principle that as soon as the necessity for quarantine restriction is removed, steps should be taken to rescind it.

12. Detailed consideration was given to the Quarantine Principles being fostered by the National Plant Board. Amendments and clarifications were suggested to make them really workable principles.

CHAIRMAN CORY: We will now proceed to the report of the resolutions committee. This was presented by Dr. W. E. Britton.

WHEREAS, The Western Reserve University and the Case School of Applied Science have provided a room and equipment for the comfort and the convenience of this Section, therefore be it

Resolved, That we extend to the officials of the above institutions a hearty vote of thanks for their courtesies.

...It was moved and seconded that the motion be accepted. The motion was put to a vote and carried...

CHAIRMAN CORY: We will go to the report of the Nominating Committee.

MR. G. M. BENTLEY: The Nominating Committee has the following report to give:

Chairman of the Section: K. C. Sullivan Jefferson City, Missouri.

Secretary: Dr. S. B. Fracker.

Signed by Messrs Guyton, Flint and Bentley.

Upon motion duly made and seconded it was voted to adopt the report...

CHAIRMAN ELECT SULLIVAN: I wish to thank the members of the Section very much. I shall endeavor to preside in a way that will continue the work as it has been carried on in the past.

Is there any further business?

MR. E. R. SASSCER: I had a note given to me just before leaving Washington. I think it would be of interest to all of those who are here. The Fourth of March means a great deal to us in this country, especially every four years. I didn't know what significance the Fourth of March had on quarantine work.

However, I find that on March 4, 1881 California passed the first real quarantine act. Therefore, the Coming March 4 will be the fiftieth anniversary. Strange to say, on the same day and in the same year Canada passed a similar act.

CHAIRMAN ELECT SULLIVAN: If there is no further business the meeting will now adjourn.

. . . The meeting adjourned at five o'clock. . .

Scientific Notes

Another Parasite of the Sunflower Weevil, *Desmoris fulvus*, (Lec). A previous report of a parasite of the Sunflower Weevil, *Desmoris fulvus*, (Lec.) was published in the February, 1930 issue of the JOURNAL OF ECONOMIC ENTOMOLOGY. The parasite there recorded was collected during the fall of 1928, and was present in very small numbers. Further studies being carried on with the Sunflower Weevil during the fall of 1929 brought to light another, and probably very important, parasite of this pest.

Parasites were found in eleven of the twenty-eight lots of seeds examined during the winter of 1929–30. These were sent to Dr. T. H. Frison in two lots and it was determined by him that the first lot contained: 1 female *Zatropis incertus* (Ashm.), 1 male *Eurytoma* sp., and 4 males and 27 females *Microbracon mellitor* (Say). The second lot had 16 *Microbracon mellitor* (Say), sex undetermined. It is believed that the latter may be an important parasite, as it was noted that it appeared to have its life cycle adjusted to its host so that the most heavily infested lots of seed also showed the heaviest parasitism. Parasitism was also found to be most abundant in areas where the sunflowers had been grown for a number of years.

J. H. BIGGER, *Illinois Natural History Survey*

Reproductivity of Flies Exposed to Pyrethrum Sprays. The claim is often made by manufacturers of pyrethrum products that the insects which are paralyzed by pyrethrum sprays but which recover after exposure are incapacitated in their reproductive powers and, as a rule, are so weakened that they are incapable of serving as potential pests. The writer conducted several experiments to test the validity of these claims as far as houseflies are concerned. Several hundred flies were exposed to pyrethrum kerosene sprays at a concentration of one pound pyrethrum extract per gallon of kerosene, a concentration which only the better household pyrethrum insecticides contain. Those flies which recovered after the first and the second days were placed in cages and given milk as food. Subsequent examination proved that not only were the flies active and ready feeders but that the females oviposited and reproduced normally, as checked by flies unexposed to sprays. Second and third generations from the flies exposed to pyrethrum sprays were reared.

NATHANIEL TISCHLER, *Iowa State College, Ames, Iowa*

A Satisfactory Nutriment for Adult Houseflies. Various investigators resort to a diet consisting of several food stuffs in the rearing of houseflies, and, therefore, the writer thought that this note might be generally useful. Based on two years' experience in rearing houseflies the year round, he found that bread soaked with milk is an entirely adequate nutriment for adult houseflies. That the bread serves merely as an absorptive medium for the milk was checked by several experiments in which flies were fed milk alone in watch glasses. It is not necessary to supplement the milk with yeast, meat broth, sugar, etc.; the flies breed and live normally on a milk diet alone. However, it must not be overlooked that it is entirely possible that the flies receive certain vitamin essentials from the fermented milk, for the milk is readily fermented at the temperature at which the flies are reared, 85°-90° F.

It is essential that the flies be fed at least twice daily, preferably three times a day; for experience proves that high mortalities occur otherwise.

NATHANIEL TISCHLER, *Iowa State College, Ames, Iowa*

Notes on the Control of the Head Louse, *Pediculus humanus capitis* DeGeer, with Benzol.—From time to time during the last fifteen years we have been called upon for treatments for this louse. The several common treatments have been advised or applied according to the nature of the cases and the treatments available. During the last four or five years benzol (commercially pure or 90 per cent) has been used. A considerable number of cases have been treated and benzol has been found to be effective with one treatment thoroughly made. It is either atomized or sprinkled over the head and rubbed in with the hands, as it appears to be necessary to moisten the eggs with benzol to make the treatment thorough. The head is then covered with a moist heavy towel until the burning sensation is felt, then the towel is removed and the hair dried. The hair appears to be benefited by the treatment as it is left lustrous and soft rather than harsh and dry as after some of the other treatments. Care should be used not to get the benzol inside of the ear or in the eyes; while it has not been observed to cause any injury to the ears or eyes when it has accidentally gotten into them, it is rather painful for a few minutes. As benzol is inflammable it should not be used near an open flame.

D. C. PARMAN, *Associate Entomologist, Bureau of Entomology, U. S. Department of Agriculture, Uvalde, Texas*

Burying Peach Drops to Prevent the Escape of Plum Curculio Adults.—The collection and destruction of drops from peach orchards is a general practice in the South to supplement the spraying or dusting for the control of the plum curculio. Growers employ several methods for making infested peach drops harmless, namely, burying, burning, boiling, and submerging in large bodies of water. Burying has been especially recommended, and is used by most growers as it is considered safer and is often more convenient than the other methods of disposing of drops; however, there has been a question as to how deep they should be placed beneath the soil to prevent the escape of curculio adults that emerge from them. In order to answer that question, an experiment was conducted during the 1930 season by burying a quantity of peach drops beneath different depths of soil and recording the curculio adult emergence. Special boxes were constructed for the experiment, and these contained sufficient soil in the bottom for pupation. The results of this experiment are given in the following table.

Box No.	Quantity of drops	Buried beneath soil to depth of	Curculio adult emergence	
			Period	Number
1	1⅝bu.	4in.	June 6–July 10	221
2	1 ¼bu.	8in.	June 6–July 10	245
3	⅞bu.	12in.	June 6–July 1	566
4	⅞bu.	18in.	June 6–July 1	51
5	¾bu.	Check (no soil on top)	June 6–July 5	173

The comparatively low emergence from the check box was probably due to the heating of the drops in that box. The results of the experiment show that peach drops must be buried deeper than 18 inches below the surface of the soil to prevent the escape of adult curculios emerging from them.

OLIVER I. SNAPP and J. R. THOMSON, *U. S. Peach Insect Laboratory, Fort Valley, Georgia*

Diabrotica balteata Lec.—This beetle was taken by Mr. Warwick Benedict and myself at Yuma, Ariz. on April 3, 1924, and at Calipatria, Calif. on April 4, 1924. On September 22, 1927 it was found in some numbers on pepper plants in the Mission Valley, near San Diego, Calif. (Pan-Pac. Entom. V, 1928, 3, p. 116). It was reported as occurring at San Marcos, near Escondido, Calif. during September and November 1928 by Prof. E. O. Essig. (Pan-Pac. Entom. V, 1928, 2, p. 66). During June and July of 1929 it was observed on peppers and nightshade (*Solanum*) near Vista, Calif., and from June to August or September of the same year it was present at San Juan Capistrano, Calif., where it became exceedingly numerous during the season of 1930. On December 26, 1930 a single specimen was taken at Costa Mesa, Calif.

From the above data it would appear that the insect is working its way northward along the coast of California at the rate of about 25 miles a year. There is at present no data to show how fast it is spreading inland, but it will probably eventually spread to all the inland valleys. The life history of this beetle is not known to me. In the adult stage it appears to be rather a general feeder. Commercial damage has so far been reported only from San Marcos, where *Diabrotica balteata* was feeding upon mulberry in company with *D. trivittata* Mann. and *D. soror* Lec., but as it represents a potential pest in this state its progress is being watched with some interest.

A. C. DAVIS, *Santa Ana, Calif.*

A Leafhopper Injuring Peach. During the season of 1928 considerable injury by leafhoppers was noted in a number of peach orchards in Maryland. In 1929 there was a material increase in injury, and in 1930 it was quite severe in a few isolated orchards. Some specimens of the 1930 material were submitted to Dr. R. H. Beamer of the University of Kansas, who determined them as *Erythroneura pleua* Beamer (Annals of the Ent. Soc. Am., Vol. XXIII, No. 3, 1930). Dr. Beamer's type material was collected in Kansas and Illinois, but the host plants were not recorded; therefore; it would seem that this is the first host recorded for this recently described species. This leafhopper belongs to the *obliqua* group of the genus *Erythroneura*, and is similar in markings to several other species of this group. There is an orange-colored inverted V on the vertex, the arms of which extend across the pronotum; three pairs of oblique orange stripes on the tegmina, and usually two fuscous black spots before the cross veins. The undersurface is dark grayish and black in color.

The injured peach foliage shows a white stippling on the upper surface which is caused by the feeding of both nymphs and adults on the under surface. Continued feeding causes the stippling to coalesce, which gives the leaves a very pale appearance. Most of the feeding takes place on the lower and inner parts of the tree and a preference is shown for the oldest leaves. Young shoots which grow out from the trunks and larger limbs show a very decided graduation of injury from the base to the tip. When the infestation becomes very heavy, there may be some discoloration of the fruit by excreta.

No detailed study of the biology of the species has been made, but in 1930 two full generations were observed. The first generation adults were observed from June 15 to July 20. No data was secured on oviposition of the first generation, but the second generation eggs were observed from July 1 to August 4. The eggs are placed in the smaller veins of the leaves. A careful search was made for eggs in the larger veins, midribs, and young twigs, but none were found. The second generation adults began to appear about August 15. Adults were present about the trees when the leaves began to drop in the fall; therefore, the indications are that this species passes the winter as adults.

The second brood eggs were found to be heavily parasitized by *Anagrus epos* Gir. This parasite was identified by Mr. A. B. Gahan. Several collections of leaves infested with eggs were made and the average parasitism was found to be about 60%. The parasites emerge from either surface of the leaves.

H. S. McConnell, *Maryland Agricultural Experiment Station*

Attractants for the Male Gipsy Moth. This problem, the details of which will appear later in more complete form, has been investigated for a period of years. As it is not known whether the results accomplished could be used for species other than the gipsy moth, *Porthetria dispar* L., it seemed advisable to make available this preliminary summary so that the information might be accessible to those working upon similar problems.

The male gipsy moth is strongly attracted to living virgin females. A scent is given off from the vicinity of the copulatory-pouch opening and is sensed by the male through its antennae.

Some males fly as far as 2.08 and 2.38 miles, but usually the distance of flight is much shorter; so the catch of males recovered is dependent upon a number of factors such as distance, wind, temperature, and topography.

Certain extracts made from the region of the female's genitalia attract males, for the attractant is soluble in a number of fat solvents such as ether, benzol, xylol, gasoline, etc. None of the attractant was found in glands of the reproductive system internally, but in the vicinity of the copulatory pouch opening setae and pores peculiar to this region were located, and it is possible that the attractant arises here, for extracts of this portion of body wall tissue attracted many males. The attractant is of a complex fatty nature, and is saturated. Owing to the continuous generation of the attractive compound by hydrolysis, it is active for several weeks when exposed, the period of activity being equivalent to the flight season of the males. The attractant is fairly stable in cold storage and from two-fifths to three-fifths of its value is retained at the end of one year.

At the moment the female emerges little of the attractant can be extracted, but the quantity rapidly increases thereafter for at least one day. Virgin females attract males as long as they live, but generally do not attract them after they have once

mated. Although considerable attractant may be extracted from females soon after mating, the quantity that can be extracted thereafter decreases rapidly as the time after mating increases.

Material for the traps is obtained by clipping the last one or two abdominal segments (or "tip") of 15 to 30 female moths into one-half an ounce to 1 ounce of solvent. Then take a 3-ounce tin can with top left off, fill it with cotton, fasten the can to a tree trunk with a nail, invert the can, pour the solvent containing the "tips" over the cotton, and invert the can to prevent entrance of rain. About 1 square foot of a sticky tree-banding material was applied to the tree trunk around the trap to catch the males attracted.

Results indicate that the practical value of the use of extract traps may be improved by (1) increasing the number and proportion of female moths obtained from available pupae, (2) determining the best method and best absorbent material for exposing the extracts in the field, (3) removing the female abdominal "tips" when they reach the age that yields the greatest quantity of attractive substance, (4) improving the extracts, and (5) preventing deterioration in storage.

Some new and important infestations in border-infested territory, and in New Jersey, were discovered by the use of traps containing extracts of female abdominal "tips." The use of an extract instead of living females in the traps has the following advantages: (1) It can be preserved for one or more years; (2) it is not necessary to visit the traps except to put them out and remove them at the end of the season, and (3) the danger of starting new infestations is eliminated.

C. W. COLLINS and S. F. POTTS, *U. S. Bureau of Entomology, Melrose Highlands, Mass.*

PACIFIC SLOPE BRANCH MEETING

The sixteenth annual meeting of the Pacific Slope Branch will be held in Pasadena California, June 17, 18, and 19, 1931. In addition to the regular sessions trips are planned to the new parasite laboratory at Riverside, to the county insectaries where beneficial insects are produced in quantities, to the local Federal laboratories, and other points of interest. Entomologist's headquarters will be at Hotel Constance, 940 E. Colorado St., Pasadena. Rates will be $2.50 to $4.00 per day single, and $4.00 to $5.00 per day double.

The summer meeting of the A. A. A. S. and of the Pacific Division, A. A. A. S. will occupy the entire week, June 15 to 20.

ROY E. CAMPBELL,
Chairman.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

APRIL, 1931

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $3.00 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

Separates or reprints, if ordered, when the manuscript is forwarded, will be supplied to authors at the rates given below. Note that the number of pages in a reprint may be affected somewhat by the make-up, and that part of a page is charged as a full page. Carriage charges extra in all cases. Shipment by parcel post, express or freight as directed.

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ANNUAL SCIENTIFIC MEETINGS: 1931-1932, New Orleans; 1932-1933, Atlantic City.

The death of JOHN HENRY COMSTOCK marks the end of a remarkable career. He was largely self-educated. He created a place for himself in a developing University. He contributed much to the growth of that Institution. It was he who made a modest University Department into one of the largest and most influential centers for entomological training. The graduates of this Department are to be found in many important positions. They were inspired by their devoted leader and loving friend. Many of them have, likewise, made material contributions to various phases of entomology. The secret of success is found in a whole-hearted devotion to truth, ability to read the secrets of nature, and *the reading*. Our departed leader and friend read while others slept. By systematic utilization of hours free from interruption, he accomplished much which otherwise would have been impossible. The hours of three to seven in the morning are usually free from interruption. They are available to most investigators. Few care to modify schedules and recognize limitations necessary for such a program. Comstock did this year after year. It is not surprising that the accumulated efforts of many quiet hours of study should result in the series of classic volumes on insects. They were not mere compilations. They were the results of interpretations based on exhaustive researches. Genius has been defined as capacity for hard work. Nothing will take the place of effort. The career of Comstock exemplifies what may be accomplished in this land of equal opportunity.

Somewhat exceptional conditions may have aided in the realization of his dreams. It is certain that his devoted wife was of no inconsiderable aid. Both captured and held the love and admiration of their students. The door of opportunity has by no means closed. There are as promising openings today as there were sixty or more years earlier. We of the present may rely upon the foundations established by our predecessors. We should find it possible to use to advantage many facilities which were unknown in earlier years. It is more than probable that some of the present generation have the necessary ability. Do they possess the genius or, in other words, the capacity for well directed hard work?

Obituaries

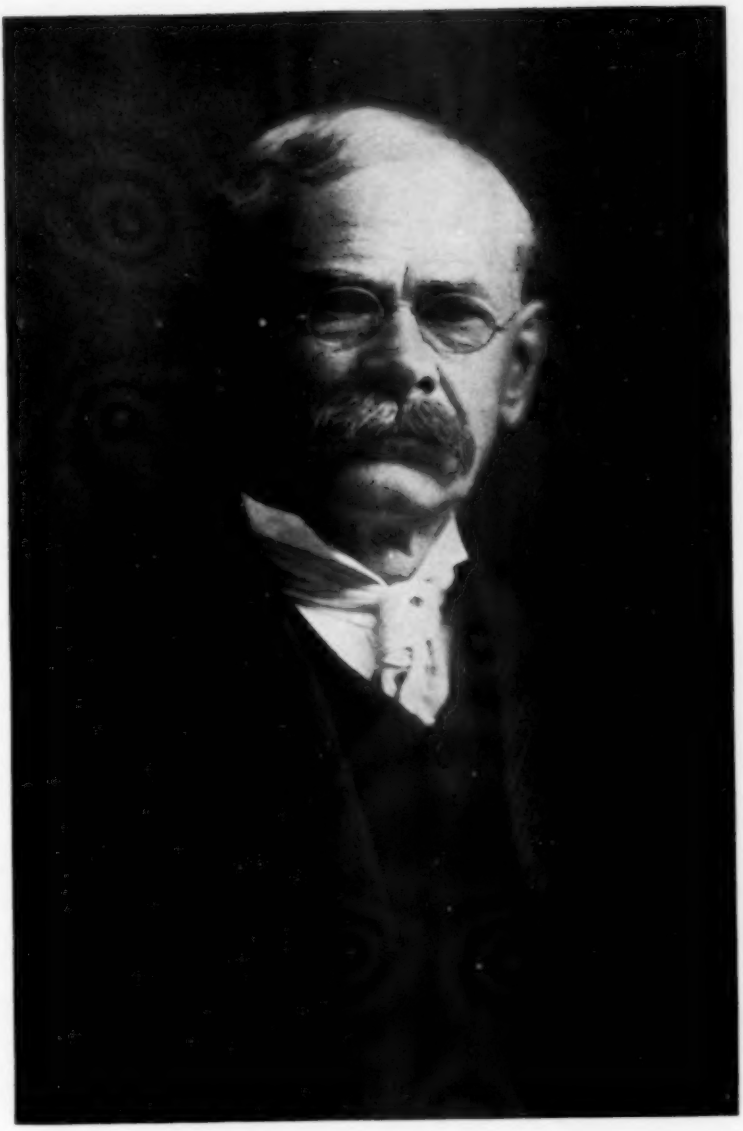
JOHN HENRY COMSTOCK

Born February 24, 1849; died March 20, 1931

In the history of this country the year 1849 will ever connotate days of adventure in search of that romantic but elusive metal the world calls gold. In that year the father of John Henry Comstock left his wife and his only child in Janesville, Wisconsin, where the son had been born, and started westward for the El Dorado of his imagination. But cholera broke upon the venturing group and laid its deadly hold upon the father.

When the long belated news of this calamitous event finally reached the little home in Janesville, the mother decided to return with her infant son to her native State, New York. Here, however, the struggle for existence grew progressively more and more severe until finally from sheer necessity the boy was placed in an orphan asylum. Later, after passing short periods in the homes of different relatives, the boy fortunately found a home with Captain Lewis Turner, a retired sailor. The three sons of Capt. Turner were sailors on the Great Lakes and naturally the boy Comstock when he reached the age of 16 became a sailor in vocation though not in spirit. A student from the beginning, he spent his summers on a boat sailing the Great Lakes in order to earn enough money to defray the expenses of attending school during the winter months. He had become interested in botany, especially in the Cryptogams and during one of the stops in the harbor of Buffalo he went to a second-hand book dealer's shop in quest of a book which would give him information regarding lichens and mosses. In his search he came across that entomological classic, Harris' Insects Injurious to Vegetation, a fortuitous event that decided his life work, and gave to the developing science of entomology one of its masters.

Plate 17



John Henry Comstock

By dint of strenuous effort Comstock became able to enter Cornell University in 1869 from which institution he was graduated in 1874. While yet an undergraduate he was called upon to give a course in entomology which led to his passing rapidly through the grades of assistant, instructor, assistant professor in 1876, and Professor of Entomology and General Invertebrate Zoology in 1882, which position he held until his retirement in 1914, at the age of 65.

In the summer of 1872 Professor Comstock spent some weeks in the study of entomology with Dr. H. A. Hagen who had lately come to the Museum of Comparative Zoology in Cambridge, Mass. Professor Comstock has told the writer of his experience as a student with Dr. Hagen. The latter, a large man, would enter the room in the morning, remove his coat, take a comfortable chair at a long table covered with insect cases, light his large German pipe and say to Comstock, "Kom here und I vill tell you some dings vot I knows aboot insects." To the young man aflame with zeal for his chosen science it was an inspiring and memorable summer.

For some time during 1874–75 Comstock pursued graduate work at Yale University where, if the writer recalls correctly, he was a student of A. E. Verrill in invertebrate Zoology. Later, in 1888–1889 he was a student in the laboratory of Leuckart in Leipzig where contact with this inspiring zoologist became one of the great stimulating experiences of his early life.

The period from 1879 to 1881 during which he was United States Entomologist at Washington, D. C., marks his chief effort in the field of economic entomology. It was during this period that his basic studies of scale insects were made and his report on cotton insects and the reports of the entomologist for the year 1879 and the year 1880 were made. On his return to Cornell University, however, he published his second report on scale insects and continued his activity and interest in economic problems through the following years as late as 1891. It was in 1891 that he and M. V. Slingerland published the results of their extensive studies on wireworms as Bulletin 33 of the Cornell University Agricultural Experiment Station. Although his actual work with economic problems ceased about this time, his interest in applied entomology remained to the end.

Prof. Comstock's bent as a seeker and investigator was born with him and began to assert itself outwardly in published papers as early as 1872. His ability as a researcher grew with the years and expressed itself most forcibly in his papers on the Coccidae, his essays on the Descent of the Lepidoptera (1892) and on Evolution and Taxonomy (1893) and his

papers in collaboration with Dr. J. G. Needham on The Wings of Insects (1899). Subsequent papers embodying results of research appeared during the following years, particularly on the palpi of male spiders, the silk of spiders, the evolution of the webs of spiders, *et al.*

Comstock's work as a teacher and organizer of the Department of Entomology at Cornell led David Starr Jordan, President of Leland Stanford Jr. University to invite him to organize a similar department at that University. Accordingly, his winter vacations, (he taught at Cornell during the summers) from 1891 to 1900 were spent at Stanford where with Dr. Vernon L. Kellogg he organized and conducted the work in entomology on practically the same basis as at Cornell.

His early struggles in self education unquestionably produced a mental tendency to obtain a clear, precise, logical arrangement of a problem in his own mind with the result that he always presented his subjects to his students with a similar degree of clearness and conciseness. This quality of Prof. Comstock, together with his infectious enthusiasm and his personal interest in his students made him a great teacher. Moreover, this quality of mind and thought together with his experience as a teacher, contributed to his success as a writer of text-books, exemplified by the Manual for the Study of Insects and the later, more complete work, An Introduction to Entomology.

Professor Comstock was a loyal friend of youth and during his life he gave pecuniary aid to many deserving young men. The Comstock home was always open to the students of the University and the cordial degree of sympathy and hospitality enjoyed in the home will remain a precious memory to scores of men and women all over the world.

Prof. Comstock, as the result of several cerebral hemorrhages, lay helpless for nearly five years, a state he accepted with great patience and a cheerful philosophy. On the night of Thursday, March 19, he suffered a final shock and during the early morning of Friday, March 20 he succumbed. On the following Tuesday, March 23, his friends laid his ashes to rest beside those of Mrs. Comstock, in Lakeview Cemetery at Ithaca on a beautiful site overlooking the valley and Lake Cayuga, a view they loved so dearly.

G. W. H.

Plate 18

George Gooding Ainslie

UNIV. OF CH.

GEORGE GOODING AINSLIE

By W. H. LARRIMER and J. S. WADE

The many friends of Mr. GEORGE G. AINSLIE were greatly shocked to learn of his sudden death of heart disease at Washington, D. C. during the night of December 19, 1930. At the time of his death he was employed as Associate Entomologist of the U. S. Bureau of Entomology with permanent headquarters at the West Lafayette, Indiana, laboratory. He had just arrived in Washington for a special assignment to study during the winter in the U. S. National Museum.

George Gooding Ainslie was born at Rochester, Minn., March 7, 1886. He was a son of Charles Nicholas and Ada L (Gooding) Ainslie. Most of his boyhood was spent at Rochester where he attended common and high school. Mr. Ainslie was graduated by the University of Minnesota, with the degree of Bachelor of Science in Agriculture, in 1908; he received the degree of Master of Arts from the University of Tennessee June 4, 1924; he was engaged as assistant to the State Entomologist of Minnesota from May 7, 1906, to December 1907, inclusive, and as Agent and Expert by the Bureau of Entomology, U. S. Department of Agriculture, on temporary appointments from May 26, 1908, to January 1, 1909, and from May 17, 1909, to August 15, 1909. He married Mattie L. Baumgarten, August 16, 1910. Their children are Paula Louise and George Lewis. He was associate professor of Zoology and Entomology in Clemson Agricultural College, South Carolina, in 1909 and 1910. Mr. Ainslie entered the service of the Federal Bureau of Entomology on July 1, 1910, and was engaged for a number of years in active field work in Tennessee and adjacent States. He resigned January 31, 1927, and entered private business, but again accepted appointment in the Federal Bureau on November 16, 1929.

In addition to his work on insects attacking cereal and forage crops, he was particularly interested in the taxonomy and biology of the Crambidae and in the Aphididae and published a number of valuable papers treating on these groups. He was fellow of the American Association for the Advancement of Science, an active member of the American Association of Economic Entomologists, and a member of the Entomological Society of America and of the Entomological Society of Washington. He was also a member of Sigma Xi and Alpha Zeta.

His record was that of work of unusual usefulness in a little known field. A native bent for observation of nature inclined him early in boyhood to the study and collection of insects. In this he later developed interest and an enthusiasm that were contagious and highly stimulating

to his professional associates. His published papers evince close and thoughtful observation and wide and attentive reading. Personally he possessed a charm and an individuality which enhanced interest both in his written words and in his informal conversation. His many friends will mourn his passing. In his death Economic Entomology has sustained a very real and genuine loss.

LIST OF ENTOMOLOGICAL WORKS BY GEORGE G. AINSLIE

1910. Papers on cereal and forage insects: The cowpea curculio (*Chalcodermus aeneus* Boh.). U. S. Dept. Agr., Bur. Ent. Bul. 85, pt. 8, pp. 129–142, illus., bibl. (Reprinted, 1911.)

1910. The larger corn stalk-borer (*Diatraea saccharalis* Fab.). U. S. Dept. Agr., Bur. Ent. Circ. 116 (revision of Circ. 16, by Dr. L. O. Howard), 8 pp., illus. (Reprinted as Farmers' Bul. 634, 8 pp., illus.; revised and reprinted as Farmers' Bul. 1025, 12 pp., illus.)

1914. The Western corn root worm (*Diabrotica longicornis* Say). Jour. Econ. Ent. 7: 322–324.

1915. A new aphid from Florida. Canad. Ent. 47: 85–88.

1916. Notes on crambids. Jour. Econ. Ent. 9: 115–118.

1917. Crambid moths and light. Jour. Econ. Ent. 10: 114–123, illus.

1917. The lesser corn stalk-borer. (*Elasmopalpus lignosellus* Zell.) U. S. Dept. Agr. Bul. 539. 27 pp., illus., bibl. (With Philip Luginbill.)

1918. Contributions to a knowledge of the Crambinae of North America. I. [*Crambus hemiochrellus.*] Ann. Ent. Soc. Amer. 11: 51–62, illus.

1918. Color variation in pupae of *Terias nicippe* Cramer. Ent. Soc. Wash. Proc. 19: 78.

1920. The cornpith weevil (*Centrinus penicellus* Hbst.). Jour. Econ. Ent. 13: 271–280, illus. (Description of last-instar larvae by Böving, A. G., pp. 277–280.)

1921. Biology of the smartweed borer, *Pyrausta ainsliei* Heinrich. U. S. Dept. Agr., Jour. Agr. Research 20: 837–844, illus., bibl. (Separate K-93.) (With W. B. Cartwright.)

1922. Biology of the lotus borer (*Pyrausta penitalis* Grote). U. S. Dept. Agr. Bul. 1076, 14 pp., illus., bibl. (With W. B. Cartwright.)

1922. Contributions to a knowledge of the Crambinae. II. *Crambus laqueatellus* Clemens. Ann. Ent. Soc. Amer. 15: 125–136, illus.

1922. The corn leaf-tier, *Lerema accius* S. & A. Fla. Ent. 6: 1–4, 10–14.

1922. Webworms injurious to cereal and forage crops and their control. U. S. Dept. Agr. Farmers' Bul. 1258, 16 pp., illus.

1923. The Crambinae of Florida. Fla. Ent. 6: 49–55, bibl.

1923. [Contributions to a knowledge of the Crambinae of North America. III.] Striped sod webworm, *Crambus mutabilis* Clemens. U. S. Dept. Agr., Jour. Agr. Research 24: 399–414. (Separate, K-106.)

1923. [Contributions to a knowledge of the Crambinae of North America. IV.] Silver-striped webworm, *Crambus praefectellus* Zincken. U. S. Dept. Agr., Jour. Agr. Research 24: 415–425. (Separate K-107.)

1923. A corn feeding geometrid, *Pleuroprucha insulsaria* Guen. Ohio Jour. Sci. 23: 89–101.

1927. Additions and corrections to the list of the Crambinae of Florida. Fla. Ent. 11: 12–14.
1927. The larger sod webworm (*Crambus trisectus* Walker). U. S. Dept. Agr. Tech. Bul. 31, 18 pp.
1930. The bluegrass webworm (*Crambus terterellus* Zincken). U. S. Dept. Agr. Tech. Bul. 173, 26 pp., illus.

Reviews

WILLE, JOHANNES:—**"Die Rübenblattwanze,** *Piesma quadrata* **Fieb."** Monographien zum Pflanzenschutz 2. 116 pages. 36 text figures. Julius Springer, Berlin. Price RM 9.60.

This monograph of the beet leaf bug gives the results of careful and thorough investigations into the biology and economic importance of this insect. The subject matter includes synonymy and systematic position, host plants, geographic distribution and region in which economic injury occurs, morphology, biology, the curly-leaf disease transmitted by the insect, control of the disease and the insect. A bibliography is appended.

Although this insect occurs throughout Europe from Great Britain to Russia and from Scandinavia to the Alps at altitudes under 600 meters, it is at present a pest of beets in certain areas in central and eastern Germany only. Its host plants include certain wild species of the Chenopodiaceae and all cultivated varieties of beets, including the edible beets, sugar beets, and fodder beets. The principle injury caused by the insect is the transmission of curly-leaf disease, a virus disease distinct from the curly-top of beets common in western North America. The insect can also transmit the disease to spinach. The monograph is well written, clear, precise, and detailed in exposition, both in respect to the insect and the disease transmitted by it. In view of the fact that in eastern United States we have all the necessary environmental factors for the successful establishment of this insect, including the favorite wild host plant, *Chenopodium album*, this monograph should be of particular interest to American entomologists. The control measures advocated are explained in detail and appear practicable.

R. B. FRIEND, *Conn. Agric. Exp. Station, New Haven, Connecticut*

A Textbook of Agricultural Entomology by KENNETH M. SMITH, pages I-XIII, 1-285, 79 text illustrations, Cambridge: at the University Press; New York: The Macmillan Company, 1931.

This excellent volume is a comprehensive summation of our knowledge respecting the agricultural insects of England, excepting those of fruits. It is systematic and descriptive in treatment, with especial attention to the more important species. The author discusses the natural or weed hosts of the pests as well as the farm crops, and has given natural enemies and general farm sanitation or clean culture unusually full treatment.

There is a general introductory chapter with an excellent selected bibliography, a chapter on methods of insect control and their application in farming practice and another on the effect of weather conditions on insect outbreaks. These are followed by chapters on the various insects of economic importance, the discussion of plant

lice being particularly full and interesting. This is also true of the account of the gall midges, especially the species affecting grains and grasses. This matter is based largely upon the studies of Dr. H. F. Barnes and is a very suggestive chapter for anyone desiring to attempt work of this character in America. There is also a most interesting account of insects and virus diseases of crops. The two appendices are worthy of special notice. One has a tabulation of the characteristic symptoms of insect attack, and the other a list of the common farm weeds in relation to insect pests. The former is designed to facilitate the recognition of the insect through its work, and the latter to emphasize the importance of general farm sanitation in its broader applications. This little work is worthy of careful study on the part of all interested in various phases of applied entomology.

E. P. FELT

SPEYER, WALTER 1929:— **"Der Apfelblattsauger, *Psylla mali* Schmidberger."** Monographien zum Pflanzenschutz 1. Julius Springer, Berlin. pp. 127. Text figs. 59.

This monograph is a treatise on the biology, economic importance, and control of the apple sucker, an insect native to Europe but recently introduced into the Maritime Provinces of Canada. The author gives the taxonomy, host plants, geographical distribution, morphology, development, habits, natural enemies, control, and extent of injury. Although most of the author's observations were made in the Lower Elbe region in Germany, reference is made to results of the investigations of other workers, and the monograph summarizes the available information.

The apple is the preferred host and the only one of great economic importance. Although the adults have been found on other fruit trees, it is questionable if extensive reproduction occurs on them, and the presence of apple trees is the most important factor affecting the distribution of the insect. Injury by the apple sucker has been reported from most of western, central, and eastern Europe, including the British Isles and Russia, and from northern Japan, Queensland (Australia), and Nova Scotia. The author briefly discusses climatic conditions in reference to distribution.

The section devoted to morphology covers the important points in external and internal anatomy of the adults and the immature stages, and that part concerned with development includes field and laboratory observations. There is only one generation a year, the eggs being laid in the early fall and hatching in the following spring (April). The adults are found from the end of May until the middle of October in Europe.

Under Habits the author deals with the general biological characteristics of the different stages and their relations to the environment, including the preference shown by the insect for various host plants and the effect of feeding on the host.

The natural enemies include a few birds and several predaceous insects, but insect parasites are relatively scarce. The author found no nymphal parasites in the course of his own investigations. In one area the adults were found not infrequently parasitized by a Cecidomyid. Fungous diseases are not important in the Lower Elbe region, although in other regions, especially Canada, they may markedly affect the abundance of the insect.

Various control methods are discussed, technical, biological, and cultural. The author considers a dormant spray of carbolineum (tar oil distillation product) used

as an ovicide to be in general the most effective and practicable technical control method. Following his general discussion of control methods the author gives a brief consideration of the injury caused by the insect in the Lower Elbe region and then takes up the organization of control methods.

This work is comprehensive in its scope and a valuable source of information concerning a pest recently established in North America. A very extensive bibliography is appended.

ROGER B. FRIEND, *Conn. Agric. Exp. Station, New Haven, Conn.*

A History of Entomology by E. O. ESSIG, pages I-VII, 1-1029, 263 text illustrations. The Macmillan Company, New York, 1931.

The author has produced a most interesting volume for all entomologists at least, and one which may be read with profit and pleasure by many others. It is a history of entomology from an obviously western viewpoint. The records abundantly justify this treatment and suggest the rich field awaiting the individual who will attempt a general history of American Entomology or possibly a history of entomology worldwide in scope.

The author has given the volume a more adequate setting by including discussions of prehistoric entomology, as evidenced by fossil insects found in California, and an account of California Indians in relation to entomology. This latter includes accounts of insects known to the Indians, those which they found of value as food and also some of the Indian legends and myths based upon insects. He has even included the Indian names in various dialects for some of the more common species. There is a brief chapter on the historical background dealing with the Spanish or Mission Period, 1769–1877, the Russian Period, 1812–1841, and the early period of American occupation, 1848–1870. The systematic and Museum entomologists will find much of interest in the chapter devoted to the principal institutions in California featuring entomology, such as the California Academy of Sciences, the University of California, Stanford University, Pomona College and a number of Natural History and Entomological Societies.

There is a most interesting chapter on the important orchard mites and insects of California, covering nearly 200 pages and dealing with a large number of mites and insects. The treatment is plainly that of a resident of the Pacific Slope and usually gives some general statements respecting the history and distribution of the insect, its appearance in California and its general economic status. The European earwig, the pear thrips, the grape leaf hopper, the beet leaf hopper, the grape Phylloxera, the cottony cushion scale, the San Jose scale, the elm leaf beetle, the black vine weevil, the alfalfa weevil, the Hessian fly, fleas, the silkworm, codling moth, the Blastophaga and the honey bee are some of the better known and more important species noticed. An examination of this chapter reveals much of general interest and many entomologists will find the text and the numerous citations very helpful in following out varied lines of inquiry.

California has been a leader in the development of biological control of insects and it is not surprising that the author should devote over 125 pages to a discussion of this fascinating subject. There is a detailed history of the efforts to discover and introduce the natural enemies of the cottony cushion scale, a project which resulted so successfully that it has stimulated many activities of a similar nature. The data given in this chapter are a revelation as to the extent to which this work has been de-

veloped. Information is given concerning a long series of beneficial insects introduced with the expectation that they would be of material service in controlling their respective hosts. The tabulations of the various introductions and liberations have a distinct historical importance and in the reviewer's judgment, it is highly advisable to have these data generally available.

It is obvious that insecticides have only relatively slight sectional limitations, and the discussion of these, occupying nearly 100 pages, is naturally broader than the subject matter of preceding chapters. California has taken a leading part in the development of certain oil insecticides, namely the distillate emulsion, crude oil emulsions, crude carbolic acid emulsion, resin wash and the later miscible oils. Very interesting details with numerous citations are given concerning these and other insecticides, including the arsenical sprays, such as Paris green, London purple, white arsenic, arsenate of lead and other arsenicals. California has also played a leading part in demonstrating the possibilities of Pyrethrum as an insecticide, and we find an interesting account of the introduction and growth of the pyrethrum plant and the marketing of large quantities of the product under the name of Buhach. The insecticidal merits of the lime sulfur salt wash, later modified to the lime sulfur wash, appear to have been discovered in California. The value of flour and soap as spreaders was first brought to notice on the West Coast, and the possibilities of poison bran mashes were developed in that section of the country. The most striking of all was the discovery and development of hydrocyanic acid gas fumigation of citrus trees, a typical activity of the Southwest, and which was limited almost entirely to citrus. There is a detailed account of this valuable contribution to economic entomology and its logical extension in later years as vacuum fumigation.

California was a leader in entomological legislation and the application of quarantine to prevent the introduction of insects not previously established in the State. The somewhat isolated location of California in earlier years gave promise of much greater benefits through such measures than could be hoped for in the Eastern States, with their closer contacts with European ports, not to mention the practical impossibility of controlling, to any marked extent, the shipment of products from one State to another, separated from each other only by a political boundary. The County Horticultural Commissioners are other early characteristics of that section. California was an ardent champion of national quarantine. There is a brief chronological account of the early efforts to secure the passage of a satisfactory national quarantine law. In addition, California has passed a number of enactments designed to limit the distribution of insects restricted to relatively small areas. It has also enacted laws to promote a better control of forest insects, to provide for mosquito abatement districts, and to safeguard public health by compelling insect sanitation in hotels and mining camps.

The chapter on biography of over 270 pages contains interesting accounts of over one hundred entomologists, some very early ones. The inclusion of these is based largely on more or less direct contributions to a knowledge of the insects of California. European entomologists and men from other countries as well as Americans are represented in this series. There is a general account of the individual, usually with a list of the principal publications and also a more or less complete list of the California insects described by the various specialists. In some cases there are short lists of insects named in honor of the worker. Those with a flare for the human side of entomology will find much of interest in this section of the book.

An unusual feature is the chronological table, nearly 140 pages, giving vital statistics regarding outstanding personalities of earlier years, commencing with Colum-

bus and continuing down to 1929. Naturally, most of these are entomologists and the data given here in connection with that in the biographical section relates to more entomologists than are probably listed in any similar work, unless it be a natural history directory of the world. The central column contains a multitude of brief items relating to historical events of especial importance to scientific men, such as the invention of movable type, the printing of the first book in England, the discovery of the Pacific Ocean, the observation of red corpuscles in the blood of the frog, and with these as a background, the author proceeds to list many items of a purely entomological nature, such as discoveries, important publications and the like, down to the end of 1929. It is an interesting and very suggestive compilation. The volume concludes with a detailed Index, the latter making the contained data readily available.

There will undoubtedly be disagreements with some of the many thousand statements made in this work. The reviewer has noted some typographical errors, especially in the chronological section and at least one obvious omission. There are doubtless others. It is impossible in compiling an extended work of this character to eliminate all errors. Entomologists are indebted to the author for the large amount of work involved. He has put on record many items which were likely to escape notice unless they were assembled shortly in a comprehensive account. The book itself is an admirable example of the printer's art. The printing is clear, the type well chosen, the arrangement excellent, and the binding attractive. The work is an attractive addition to any library. It should be found in all large collections of books. It will be prized by those who have an interest in the human side of one phase of science.

E. P. FELT

Current Notes

Elmer W. Beck has been appointed Junior Entomologist, Bureau of Entomology, and assigned to the sublaboratory at Monroe, Michigan.

Mr. W. B. Mabee, Extension Entomologist of Montana was appointed Assistant Professor of Entomology Extension at the Pennsylvania State College September 15, 1930.

F. C. Bishopp has been designated acting Assistant Chief of the Bureau of Entomology in the position made vacant by the resignation of Mr. J. E. Graf.

Dr. H. L. Parker's present address is European Parasite Laboratory, Avenue Godillot, Hyeres, (Var), France.

Mr. L. B. Smith, formerly of the Bureau of Entomology, Japanese Beetle Laboratory, Moorestown, New Jersey, was appointed Assistant Professor of Entomology, Extension, at Pennsylvania State College February 1, 1931.

Philip Luginbill, C. H. Batchelder, F. L. Simanton, G. T. Bottger, and V. F. Kent, of the Bureau of Entomology corn borer research investigations, participated in a conference on insecticides at Wooster, Ohio, on February 20.

Dr. Rodney Cecil, Associate Entomologist, who has been engaged on the lima-bean pod borer problem at Alhambra, Calif., established permanent headquarters at Ventura, effective February 1. Dr. Cecil's address is Box A-3, Ventura, Calif.

Frank G. Hinman, a graduate of the Montana State College, was appointed Junior Entomologist, Bureau of Entomology, January 16, 1931, and has been assigned to investigations of the pea weevil, with headquarters at Corvallis, Oregon.

Owing to the separation from the service of B. R. Coad, formerly in charge of the Division of Cotton Insects, Bureau of Entomology, the direction of this division has been taken over by F. C. Bishopp, with headquarters in Washington, D. C.

J. M. Jeffrey, who has been under appointment by the California State Board of Forestry, is now assigned to cooperative work with the Bureau of Entomology, Berkeley, California, Laboratory. The object of the study is to determine the nutritional requirements of the western pine beetle.

A cabinet for maintaining four stages of constant temperature conditions has been built into the laboratory at Berkeley, and will be used by Mr. Beal, Bureau of Entomology, in his studies for the determination of optimum temperature conditions for the western pine beetle.

E. K. Bynum has been appointed Assistant Entomologist, Bureau of Entomology, effective January 12. He is located at Houma, La., and will assist in the receiving, rearing and liberation in the United States of parasites of the sugarcane moth borer which are being received from South America.

A public service patent covering the use of ethylene oxide as a fumigant was granted on February 3 to Dr. R. T. Cotton of Bureau of Entomology and to Dr. R. C. Roark of the Insecticide Division, Bureau of Chemistry and Soils, as representatives of the Department of Agriculture.

At a meeting held on Feb. 4th, the Corporation of McGill University, Montreal, Canada, gave their approval to a course leading to the degree of Doctor of Philosophy in Entomology, to be given at Macdonald College. A new greenhouse for the use of the department is now being equipped.

G. J. Raeussler, Bureau of Entomology, has transferred his headquarters in France from Antibes to Nice. His new location is nearer to the principal localities for collecting parasites of the oriental fruit moth in southern Europe and is one of the principal ports from which shipments in that region may be made.

W. J. Reid, Jr., Bureau of Entomology, Charleston, S. C. visited Washington January 12 to January 20, to discuss the future work on suberization of pieces of potato seed as a means of preventing injury by the seed-corn maggot. This work is being carried on in cooperation with F. C. Wright and W. M. Peacock, of the Bureau of Plant Industry.

Frank H. Spencer has been appointed Business Manager of the Bureau of Entomology. Since 1926 Mr. Spencer has been administrative assistant to the Secretary of Agriculture. Prior to his assignment to the Office of the Secretary he was engaged in general administrative work in the Bureau of Animal Industry, the Bureau of Markets, and the Division of Publications.

J. K. Holloway, Assistant Entomologist, who has been engaged in the Japanese beetle project at Moorestown, N. J., since 1927, has been transferred to the oriental fruit moth project and will be engaged in parasite investigations, with headquarters at the above place. He will be concerned principally with the mass production of parasites of the oriental fruit moth and will receive foreign importations.

After a period of service of nearly 20 years, Fred E. Brooks, Bureau of Entomology, has retired from the service, effective December 1, 1930, because of disability. For a number of years he has been in charge of the work on nut insects for the Bureau of Entomology in the central Appalachian region, and has also done considerable work on the borers affecting apple trees, and on other apple insects. Mr. Brooks was a born naturalist and a keen observer. With his retirement the field laboratory at French Creek, W. Va., has been discontinued.

R. W. Burrell, Bureau of Entomology, Moorestown, N. J., is now located at Homebush, Australia, in a field laboratory. As Homebush is just outside of Sydney, Mr. Burrell retains his mailing address as, care of American Consulate in Sydney. Mr. Burrell is making a survey and study of the parasites of the Rutiline Coleoptera. Those parasites discovered to date are all Diptera; however, Mr. Burrell finds that the Thynnidae (Hymenoptera) are abundant in species and it is expected that further studies will connect this parasitic group with some of the Rutiline hosts.

A. L. Gibson, Bureau of Entomology, has completed his report of the annual forest-insect survey of the Beaverhead National Forest. This survey is conducted to obtain data relative to the spread of epidemics of the mountain pine beetle. The report shows that the infestation has spread throughout the Beaverhead National Forest, and that some 3,859,000 trees were attacked in 1930, bringing the total destruction for the last four years up to 7,000,000 trees. In the infestation of 1930 there was an increase of 1,353,000 trees over the previous year's loss. The Beaverhead infestation spread from the Bitterroot and Salmon National Forests.

A number of field leaders of the Division of Deciduous Fruit Insects, Bureau of Entomology, spent the greater part of the week of January 26 in Washington going over the work of their respective Laboratories and discussing plans for the coming season. Among those present were F. L. Campbell, Luther Brown, N. E. McIndoo, and E. H. Siegler, Takoma Park, Md., H. W. Allen and John Gray, Moorestown, N. J.; F. H. Lathrop, and Wm. P. Yetter, Jr., Vincennes, Ind.; A. J. Ackerman, Bentonville, Ark.; O. I. Snapp, Fort Valley, Ga.; G. F. Moznette, Albany, Ga., L. F. Steiner, Cornelia, Ga.; H. G. Butler, Harriman, Tenn.; P. M. Gilmer, Wichita, Kans.; E. J. Newcomer, Yakima, Wash ; and G. A. Runner, Sandusky, Ohio.

Dean Thomas P. Cooper has announced the addition of Dr. C. O. Eddy to the research staff of the Experiment Station of the University of Kentucky. He will be associated with Prof. W. A. Price, state entomologist and head of the Department of Entomology and Botany of the Experiment Station and College of Agriculture. For the next few months he will study the Oriental fruit moth and codling moth in orchards in western Kentucky. Dr. Eddy received his training at the Ohio State University. He has carried on research work in Ohio, taught at North Carolina State College, and more recently has been Associate Entomologist of the South Carolina Experiment Station.

Studies on the development of broods of the western pine beetle under different conditions of temperature and moisture, which have been conducted for the past two seasons under field conditions by the Bureau of Entomology, are now being continued in the field laboratory at Berkeley during the winter months. J. A. Beal, of the field laboratory at Portland, shipped a quantity of green logs and infested bark to Berkeley, where he is temporarily located, in order to have the advantage of equipment loaned for his use in this study. The department of plant physiology

of the University of California and the Bureau of Entomology have each supplied a number of different constant-temperature chambers which are in operation.

Through the courtesy of Laurel Duval, Chief Grain Inspector of the New York Produce Exchange, the Bureau of Entomology had the opportunity to cooperate in experiments in fumigating wheat with a mixture of ethylene oxide and carbon dioxide. In these experiments instead of using dry ice as a source of carbon dioxide and introducing the mixture into the grain as it enters the bin in accordance with the method of procedure already published upon, the fumigating mixture was forced from cylinders into the grain column through a system of pipes and nozzles with which the bin was equipped. Dr. Cotton, who represented the Bureau during these experiments on February 3 to February 25, states that the results were very promising.

Dr. Neale F. Howard, Senior Entomologist, Bureau of Entomology, in charge of the field laboratory at Columbus, Ohio, visited Washington, February 3 to February 11, to consult with Bureau officials. He visited Moorestown, N. J., February 12 to February 13, to confer with Messrs. Hadley, King, and others, in regard to having a representative of the laboratory in Australia investigate parasites of the genus Epilachna in that country. Dr. Howard spent much of his time discussing problems and methods of parasite rearing, his success in rearing successive generations of Tachinid parasites of the Mexican bean beetle throughout the winter months is not a common accomplishment, and the methods used were of much interest and value to laboratory members.

J. E. Graf, who has been associated with the Bureau of Entomology for the past twenty years, has submitted his resignation, effective March 5, to become Associate Director of the United States National Museum. He was appointed an agent of the Bureau at Compton, Calif., in 1911, after his graduation from Pomona College. In 1918 he was promoted to entomologist in charge of sweet-potato weevil investigations. With the advent of the Mexican bean beetle in the East in 1920, Mr. Graf's activities were enlarged to include this problem. In 1923, he was called to Washington where he was placed in charge of the Division of Truck Crop Insect Investigations. In 1928, he was made Assistant Chief of the Bureau, in charge of Business Administration, and head of the Division of Truck-Crop Insects. Mr. Graf was also, for three years, a member of the Federal Horticultural Board, and a member of the Board of Advisors to the Plant Quarantine and Control Administration. On February 1, 1931, the administrative work of the Bureau was realigned, the position of Assistant Chief of Bureau being set up with broadened duties and responsibilities. At the same time, the position of Business Manager of the Bureau was made an independent one. Mr. Graf was appointed to the new position of Assistant Chief on February 21, 1931. Mr. Graf's services in the Bureau have been of the highest order, and he has been held in the highest esteem by the entomologists of the United States and Canada. His withdrawal is a serious loss to the Bureau and to economic entomology. The very best wishes of his associates are extended to him in his new field of activity.

Horticultural Inspection Notes

The port of Sasabe, Arizona was recently opened from a plant quarantine standpoint and Mr. C. H. Wallis, formerly stationed at Nogales, Arizona, has been placed in charge.

The Kansas State quarantine on the alfalfa weevil was amended effective October 6, 1930, to permit the importation throughout the year of alfalfa meal from approved mills in the infested areas.

Mr. W. W. Ellenwood has been appointed Chief of the Division of Plant Industry, Columbus, Ohio, to succeed Mr. E. C. Cotton, who is enlarging his fruit producing interests at Elyria.

Mr. W. H. Wicks has been appointed Acting Director, Bureau of Plant Industry, at Boise, Idaho, to fill temporarily the vacancy caused by the withdrawal of Mr. M. L. Dean from that position.

Messrs. G. L. Furr and W. C. Edgeworth have been transferred from the Pink Bollworm field force to the Mexican Border Inspection Service and assigned to the ports of Nogales, Arizona and Del Rio, Texas, respectively.

Mr. Henry Ness, Assistant State Entomologist of Iowa, and Prof. A. G. Ruggles, State Entomologist of Minnesota, visited the Federal transit inspection office at Chicago, on March 3 and 4, respectively.

Dr. W. A. McCubbin, Senior Pathologist of the Plant Quarantine and Control Administration, left on March 14 for Cuba, to secure information as to certain diseases of beans and other truck crops grown on the island.

Mr. D. F. Felton has been appointed as Deputy Secretary of the Nebraska State Department of Agriculture by the new governor, Charles W. Bryan. Mr. L. M. Gates is continuing in the department as Nursery and Apiary Inspector.

Two additional circulars summarizing the plant quarantine laws of foreign countries have recently been issued by the Plant Quarantine and Control Administration; they are PQCA–303, covering the Netherlands, and PQCA–304 covering Denmark.

The administrative offices of the European corn borer and Japanese beetle quarantine enforcement projects have been combined at South Norwalk, Conn., from which headquarters the two projects will be supervised by Mr. L. H. Worthley.

California quarantine circulars relating to the Cherry Fruit Fly were reissued under date of December 12, 1930, to restrict the entry of uncertified cherry fruit from the Counties of Latah and Nez Perce in the State of Idaho. Formerly the restrictions applied only to portions of Oregon and Washington.

The Oregon State legislature is reported to have passed new legislation establishing a State Department of Agriculture to take over the work of the State Board of Horticulture and various other agricultural activities in the State. The new law is to become effective on July 1.

Transit inspection work for the spring nursery stock shipping season has been resumed at Kansas City, Omaha, Denver, and Ogden, and has been started at Washington, D. C. The forces at Chicago, New York, and Spokane, have been also strengthened by the assignment of additional men.

Porto Rican Paragraphs No. 19, March 2, 1931, states that Mr. Edmundo Colon has been appointed as Commissioner of Agriculture, and that Mr. Prudencio Rivero Martinez has been appointed as Commissioner of Labor to take the place of Dr. Carlos E. Chardon, who had been Commissioner of Agriculture and Labor for several years.

A revision of the former order prescribing the routes by which citrus fruits from certain sections of Mexico were permitted to cross the United States in bond, either to other destinations in Mexico or to Canada, was issued on February 27 by the Plant Quarantine and Control Administration as Circular PQCA–305.

Since the first of the year the following men have received appointments as junior plant quarantine inspectors in the port inspection service: Messrs. C. M. Locke, J. W. Stanton, J. B. Zuck and E. L. Talbert. Mr. Locke has been assigned to the port of El Paso, Mr. Stanton to Brownsville, Mr. Zuck to Eagle Pass and Mr. Talbert to Del Rio, Texas.

Mr. Lee A. Strong, on March 3, announced the decision of the Department of Agriculture that there will be no relaxation in the regulations governing the admission of narcissus bulbs from abroad, and that the domestic quarantine regulations on narcissus will be more rigidly enforced. Mr. Strong stated that the evidence submitted at the hearing on January 29 indicated gratifying progress in clearing up pests in bulb plantings in this country.

The Southern Plant Board met at Atlanta, Ga., on February 3 and 4. Delegates from nearly all the southern States were in attendance. The members discussed the principles of plant quarantines referred back to the regional boards by the National Plant Board. The simplification of certification procedure and of the regulations governing the interstate movement of nursery stock were also considered. It was decided to hold the next or summer meeting of the Board at Asheville, N. C., at a date to be announced later.

The pressure of other duties has caused Dr. H. L. Kent, President of the College of Agriculture & Mechanic Arts of New Mexico, to turn over the plant quarantine and nursery work of that State to Prof. R. F. Crawford, Head of the Department of Biology. Professor Crawford has been appointed Deputy Inspector of the Plant Quarantine and Regulatory Office, with headquarters at State College, N. Mex., for this purpose. The 1929 legislature of New Mexico passed a new law requiring the inspection of all nurseries in the State, and providing for a fee of $10 for inspection and certification.

The Commissioner of Agriculture of Texas issued a proclamation (No. 39) on February 13, 1931 amending the citrus quarantines of June 2, 1930 (Nos. 29–35 and 37) to permit the movement under special permit and bond, of citrus and other nursery stock from the Gulf Coast States into the East Texas citrus section, i. e., the Counties of Newton, Jasper, Orange, Jefferson, and Hardin. This section, the proclamation states, is separated from other important citrus growing areas of the State, and effective intrastate regulations are in force. The modification was issued therefore "in order to afford the broadest development of the horticultural industry of the East Texas area and in order to make more effective the State defense against the invasion of citrus plant pests into this area."

Two Texas proclamations (Nos. 40 and 41) have also been issued on potatoes, effective April 15, 1931. One relates to the potato tuber moth and the potato eelworm and requires vacuum fumigation of potatoes shipped to the Lower Rio Grande Valley (Cameron, Hidalgo and Willacy Counties) from the States of California, Florida, Virginia, Tennessee, South Carolina, North Carolina and Louisiana. The other quarantine pertains to the Colorado potato beetle and requires the screening of potatoes entering the Lower Rio Grande Valley from any State.

The Oregon State Board of Horticulture established a quarantine (No. 19) on July 28, 1930 to prevent the introduction of strawberry yellows. Under this quarantine, strawberry plants may not be transported from California into Oregon.

Mr. G. F. Wheaton, one of the older plant quarantine inspectors of the State of New York, was retired on January 1 because he had reached the age requiring such retirement under the State pension system. Mr. George E. Smith of Albion was

appointed on February 9 as nursery inspector to take Mr. Wheaton's place. Mr. Smith, who is a graduate of the Michigan Agricultural College, has been engaged in Agricultural Experiment Station work in the Philippine Islands, taught agriculture in the New York State Schools of Agriculture, has been engaged in spray service work in connection with the Farm Bureau for several years and has been field service man for the Niagara Sprayer Company.

The agricultural appropriation bill for the Fiscal Year 1932 carries funds amounting to $3,747,930 for the Plant Quarantine and Control Administration. Of this amount $799,130 is assigned to foreign plant quarantines, $30,300 to the certification of exports, and the remainder to administrative work and the enforcement of the various domestic plant quarantines. In addition, the first deficiency act of 1931 carried an appropriation of $675,000 to compensate farmers in Arizona for losses sustained in the enforced nonproduction of cotton in noncotton zones. The second deficiency act made available for the next fiscal year the unexpended balance of Mediterranean fruit fly funds for the current season in the event that an emergency makes necessary the expenditure of such funds. $80,000 of the balance is also made available for research work on this pest in Hawaii, Brazil, and the West Indies.

The Central Plant Board met at Champaign and Urbana, Illinois, on March 5 and 6, respectively. Representatives of the following States were in attendance: Illinois, Indiana, Iowa, Kansas, Kentucky, Minnesota, Missouri, Ohio, and Wisconsin. Delegates from the American Association of Nurserymen and from other nursery groups as well as from the United States Department of Agriculture, were also present by invitation of the Board. The subjects discussed included alfalfa weevil quarantines, the licensing of the nursery agents, the relative importance of certain nursery pests, the Federal phony peach disease, narcissus bulb, and fruit stock quarantines, the Dutch elm disease, elm canker and wilts, and gladiolus inspection. The present officers were reelected, namely, E. L. Chambers, President, and P. A. Glenn, Secretary-Treasurer. The representatives on the National Plant Board are George A. Dean and A. G. Ruggles. The next meeting will be held during the first week of March, 1932, at Wooster, Ohio.

Apiculture Notes

At the annual Convention of the American Honey Producers League held this year at Toronto, Canada on February 9–12, the directors accepted the invitation extended to them from Ohio to hold the 1932 convention at Columbus.

Visitors of note at the Winter Meeting of the Ohio Beekeepers' Association were: Dr. James I. Hambleton, Bee Culture Laboratory, Washington, D. C.; Mr. Morley Pettit, Commercial Honey Producer and Producer of Package Bees, Georgetown, Ontario, Canada; Mr. Herman Rauchfuss, Commercial Honey Producer, Worland, Wyoming.

Professor V. G. Milum, University of Illinois, Champaign, Illinois, was the prominent out of state speaker secured by the Extension Department of the Ohio State University to lecture on the problems relating to fall and winter management of bees, during Farmers week, February 4, 5, and 6.

George E. Marvin of the University of Wisconsin, has been appointed Assistant Apiculturist and reported for duty February 2 at the main laboratory of the Division of Bee Culture, Somerset, Md. For the past few years Mr. Marvin has been working

with Prof. H. F. Wilson, Dr. E. B. Fred, and Dr. W. H. Peterson, of the University of Wisconsin, and has had wide experience in research dealing with the chemistry and bacteriology of honey.

H. B. Parks, in charge of the Division of Apiculture, Texas Agricultural Experment Station, generously presented several rare and valuable bee journals to the Beekeeping Library of the Department of Agriculture. Professor Parks has made other important contributions to the Beekeeping Library, which shows that while he is engaged in establishing a library at the State Apicultural Research Laboratory, San Antonio, Tex., he also has a keen and unselfish interest in the Beekeeping Library of the Department.

Jas. I. Hambleton, Bureau of Entomology, left Washington, January 5 for the Pacific Coast, on business relating to the establishment of the new bee-culture field station at Davis, Calif. Enroute, he visited the Intermountain States Bee Culture Field Station at Laramie, Wyo. While in California Mr. Hambleton participated in the annual meeting of the Riverside County Honey Producers' Association at Riverside. On the return trip from California he visited the Southern States Bee Culture Field Station, at Baton Rouge, La.

Dr. Warren Whitcomb, Jr., of the Southern States Bee-Culture Field Laboratory, Baton Rouge, La., represented the Bureau of Entomology at the Southern Beekeeping Conference held at Montgomery, Ala., February 18 and 19. Representatives from eleven states were in attendance at the conference, which was well participated in by all delegates. E. G. LaStourgeon, editor of the Beekeepers' Item, San Antonio, Tex., was elected president, and Prof. Jesse M. Robinson, head of the department of entomology of the Alabama Polytechnic Institute, Auburn, Ala., was elected secretary.

Notes on Medical Entomology

Herman O. Schroeder has been appointed Junior Entomologist, Bureau of Entomology, effective January 21, for duty at the field laboratory at Charleston, S. C. Mr. Schroeder is engaged in a study of ticks.

R. W. Wells, Bureau of Entomology, returned to his usual duties at the field laboratory at Galesburg, Ill., on January 9, after spending several months investigating cattle grubs in Texas and Colorado.

Fred D. Butcher, Bureau of Entomology, was one of the speakers in the recent short course for graduate veterinarians, held at the Missouri Agricultural College. He was there from January 21 to January 24, and led a discussion on botfly control. He then visited the extension departments of the Kansas State Agricultural College, the University of Nebraska, Iowa State College, and Purdue University, to make preliminary arrangements for extension work in the states in which these institutions are located.

H. H. Stage, who for several years has been the entomologist of the Cotton Belt Railroad, was appointed Associate Entomologist, effective February 13, and was assigned to take charge of the Bureau of Entomology mosquito field laboratory at Portland, Oregon. Prior to reporting there on March 2, Mr. Stage spent several days studying mosquito material in the National Museum. In company with Dr. L. O. Howard, he attended the meetings of the New Jersey Antimosquito Association, at Atlantic City, N. J., February 18 to 20.